DISCOVERY

Monthly Notebook

The Cathode-ray Tube
Clear Air Turbulence: A Menace to High-flying Aircraft

Achatina's Odyssey
Dr. W. J REES

The Ice Ship Fiasco
SIR CHARLES GOODEVE, F.R.S.

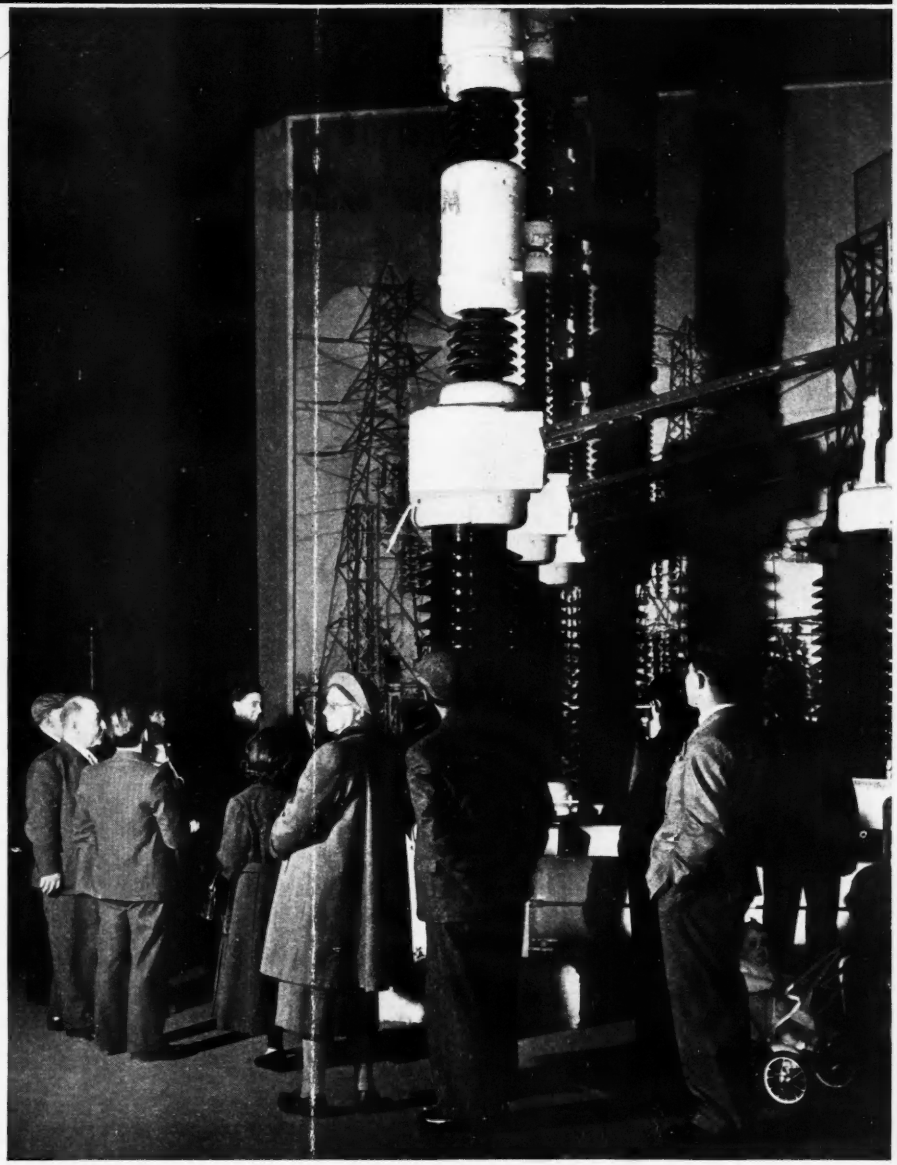
Science in Russia—I
ERIC ASHBY

Developments in Concrete
N. N. B. ORDMAN, B.Sc., A.M.Inst.C.E.

Project 'Snow Cornice'
Prof. W. E. ODELL

Artificial Rain in South Africa
KEITH PULVERMACHER

What are Allergies?
HELEN CLAIRE HOWES



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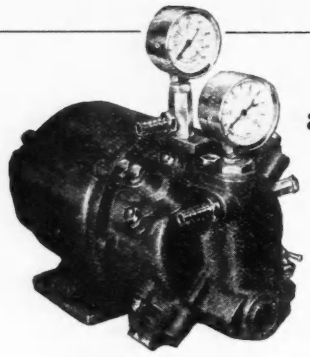

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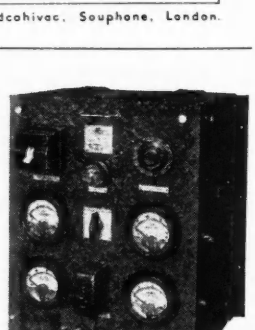

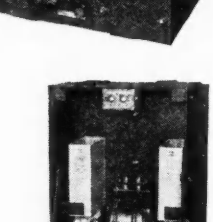

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DISCOVERY

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The Progress of Science

The Cathode-ray Tube

A DEMONSTRATION of the manufacture of cathode-ray tubes was given recently by the G.E.C. at its new Perivale factory. The occasion was a reminder not only of the great importance of the cathode-ray tube to modern technology—every major electrical firm now has a branch dealing entirely with the development and production of cathode-ray tubes—but also of the speed with which this position of importance has been reached. The cathode-ray tube is indispensable to television. It is an ubiquitous tool of research and control. It is an essential part of radar. Yet it has existed as a normally-purchasable piece of apparatus for barely twenty years, and some standard textbooks not considered significantly out of date make no reference to the cathode-ray tube and yet are still in use in schools and universities. The G.E.C. actually started manufacture in 1934, only seventeen years ago, though it is likely that experimental tubes were made perhaps as early as 1926.

The comparative youth of the cathode-ray tube—the C.R.T.—is all the more remarkable in that the basic principles were well established at about the turn of the century, from fifty to sixty years ago. Many scientists in the decade 1890-1900 worked with discharge tubes—glass tubes in which high-voltage electricity discharges through a gas at low pressure. (Rontgen discovered X-rays when working with such a tube in 1895. Our modern electrical display-signs are often discharge tubes, the most popular gas being neon, which gives the now familiar brilliant orange-red light.) In the course of the work it became known that when the gas pressure was low enough to justify the term 'vacuum', there was no luminous discharge. Instead, there was green fluorescent light on parts of the glass tube. An obstacle put between the cathode (the negative electrode) and the green light produced a sharp shadow. It was thus seen that this green light was caused by the impact on the glass of invisible rays coming from the cathode. These were, of course, what we now call 'cathode rays'; Goldstein is usually credited with having first used the expression. The French scientist Perrin demonstrated that the rays carried a negative charge of electricity though it was J. J. Thomson who clinched the matter convincingly. He also, as is well known, proved that the rays consisted of tiny particles of negative electricity—electrons—of much less mass than the lightest atom. Furthermore, after a long struggle with the best vacuum pump then available, he showed that the rays could be deflected electrostatically—that is, when an electric field was placed across their path they moved towards the positive side of the field. Crookes demonstrated that the rays could be deflected by a magnet.

At about this time, therefore, in 1897, the essentials of a cathode-ray tube were known to exist—a stream of electrons of negligible mass travelling at high speed in straight lines from the cathode, deflectable by both electrostatic and magnetic fields, and creating visible light when they struck certain fluorescent materials. In fact, one such tube was known. It was the Braun tube. In this, the beam, which, of course, spread out by the mutual repulsion of the negative electrons as it progressed from the cathode, was limited by means of a diaphragm so that a comparatively small area of screen was struck. The resulting light could hardly be described as a 'spot', but it was small enough for its movements to be seen. The voltage needed to tear electrons from the cathode was very high indeed.

At about the same time a new branch of electronics was being developed by O. W. Richardson, who coined the term 'thermionics'. He discovered the laws governing the emission of electrons by hot bodies. By making the cathode of a Braun tube a filament through which current flowed, it could be made to emit electrons easily. This reduced the voltage needed to cause discharge. The addition of certain refractory materials such as thorium oxide improved the electron-emitting properties of the hot cathode and the so-called 'Wehnelt' cathode arrived in 1905 and was incorporated in the Braun tube. One obstacle to the wider use of the tube was thus removed, though the life of the thermionic cathodes was at that time very short. Two obstacles still remained. One was the inadequacy of existing vacuum techniques, especially for commercial production. The other was the difficulty of focusing the beam, i.e. concentrating it in such a way that it would come to a point at the fluorescent screen and so make a tiny spot of brilliant light. A first move to overcome the second obstacle was made when Wehnelt thought of putting a small metal cylinder round the cathode, a cylinder carrying a negative charge. The effect of this was to force

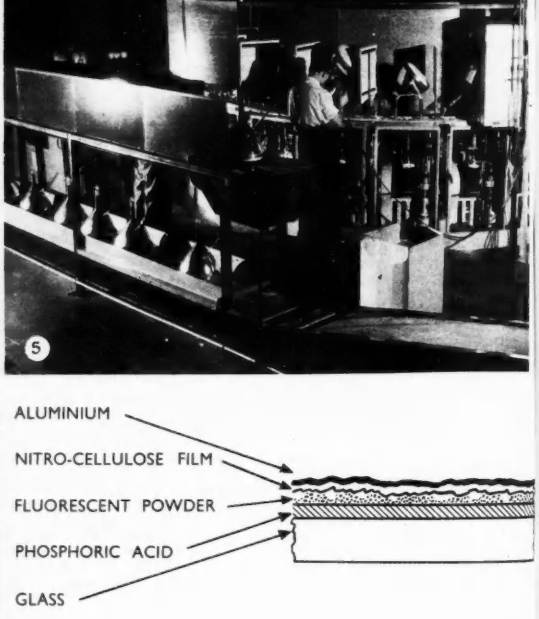

FIG. 1.—After washing on the automatic machine shown here, the inner surface of the tube is rendered sticky with a coat of phosphoric acid, on to which fluorescent powder is sprayed.

FIG. 2.—The tubes are now baked.

FIG. 3.—Next a coating of nitrocellulose lacquer is added (*see diagram*).

FIG. 4.—After partial evacuation to remove oxygen, the rear surface of the fluorescent screen is aluminised.

FIG. 5.—The C.R. tube is assembled, then evacuated on this multi-head pumping machine, and sealed off as shown here.

the electrons towards one another and thus concentrate the beam at its emergence from the cathode. It was also known that a magnetic field could concentrate the beam, but the laws of such magnetic focusing were not worked out at this time. In general, despite the Wehnelt negative cylinder, inadequate focusing remained a major obstacle for many years. It would be interesting for someone to trace definitively the precise reasons for the long delay in the production of the improved Braun tubes, or, as we can now call them, cathode-ray tubes, for the results would be important in the history of technology, and the mysteries often encountered when we try to account for delays would be cleared up. Here we can do no more than summarise them broadly—imperfect evacuating methods, inadequate focusing, and the absence of suitable thermionic valves for the circuits needed in conjunction with the cathode-ray tubes. No progress was made for another decade after the introduction of the Wehnelt cathode.

This does not mean that many scientists did not realise what a useful tool a cathode-ray tube could be. As early as 1911 Campbell Swinton proposed a television system utilising Braun tubes. However, television was then merely a futuristic project, and it was for quite another purpose that the cathode-ray tube was to be used. This purpose was the visual demonstration of oscillating current. Although electrical theory showed by means of equations that oscillating currents could be produced, and although the growing radio industry made use of such oscillations, it was difficult to get visual evidence of their nature. The study of wave-form was largely mathematical. Any instrument that makes a wave-form visible is an oscillograph, and the only successful one available until about 1930 was the Duddell oscillograph. This was to modern eyes a very clumsy affair, though in the hands of extremely skilled workers it provided very good records of oscillations. The essence of this oscillograph was that a mirror on a current-carrying strip, placed in a very strong magnetic field, vibrated with the oscillations of current going through it. At the same time another mirror oscillated at right-angles to the first and in synchronism with it. A spot of light reflected from the first mirror to the second and then to a screen or photographic plate showed a single 'wave' or 'cycle' of the oscillation. (Any antiquarian poking about in modern laboratories will occasionally find an enormous magnet from a Duddell oscillograph, dusty and forgotten but too big to be casually thrown away.) There was a very low limit to the frequencies that could be handled by such an oscillograph, for anything possessing mass even of the order of a fraction of a gramme must inevitably be limited in the speed with which it can follow accurately any changes in the current. The inertial mass of an electron, on the other hand, is negligible. A moving electron is thus an excellent improvement on a metal strip, and it must have occurred to many a scientist that the essentials for a very satisfactory oscillograph were there in the improved Braun tube. It was obvious that if two pairs of plates, one pair at right-angles to the other, were inserted in the tube and outside the beam of electrons, then oscillations of voltage on one pair of plates would make the screen spot trace out a straight line. At the same time if a voltage was applied to the second pair of plates, the trace on the screen could be spread out in time and so show the actual wave-form. This second necessity, the spreading out in time, was what we now call a 'linear time base', and the method just outlined is precisely what is used in the modern cathode-ray oscillograph. But even as recently as 1921, when a further important discovery was made, the thermionic valve had not reached the stage of efficiency and production that enabled anyone to construct a suitable circuit for producing the sweep voltage of a linear time base.

In 1921 Van der Bijl and Johnson made a discovery that brought the commercial cathode-ray tube a stage forward. It was that a trace of gas left in the glass vessel produced a focusing effect because the positive ions, produced when the cathode rays collided with atoms, acted as an attracting core and so prevented the electrons from spreading out. Many modern workers can remember that not long before the recent war there were cathode-ray oscillographs incorporating such gas-focused tubes. The addition of the screened-grid valve and the pentode valve to the armoury of thermionic valves (in 1927 and 1928 respectively) made possible the time-base circuits for these oscillographs. They were very handy instruments and pleasant to use, but they had one great disadvantage—the comparatively large mass of the positive ions made the use of high frequencies impossible. The gas-focused tubes were thus only useful for audio frequencies, whereas the demand was for tubes that would handle radio frequencies.

Meanwhile a revolution had come in evacuating techniques. Two new methods were introduced, both by Gaede, in 1912 and 1915. The second one is still used. It was improved by Langmuir in 1916. It is the method of the diffusion pump. The underlying principle of this is simple. It is merely that a vapour or gas rushing past an orifice connected to a closed vessel will cause some of the gas in this vessel to pass along with the gas stream. Thus the vessel, already partially exhausted to a very low pressure by the usual type of rotary pump, is gradually exhausted still more. The limit is set by the vapour pressure of the liquid whose vapour is used as the driving agent. Mercury has been commonly used as the working fluid and its vapour pressure is high enough to necessitate some sort of condensation stage to prevent the vapour from diffusing back into the vessel being exhausted. By making more than one stage of the whole process and by using a liquid-air trap to prevent back diffusion, successful diffusion pumps have been manufactured. They necessitate no manual operation and so can be incorporated in a production line. K. C. D. Hickman later on produced a diffusion pump utilising certain organic oils as working fluids. These have low enough vapour pressures at room temperatures to enable the designer to dispense with the liquid-air trap.

Hickman's invention came in 1930. Two years later came the solution of the focusing problem. In 1932 the science of 'electron optics' was born. German scientists found it. They showed that a stream of electrons could be made to go just where they were wanted by means of suitably shaped electrodes on which electric potentials were put. In other words, the influences were electrostatic. Any arrangement of electrodes designed to affect the direction of the stream of cathode rays became known as an 'electron lens' and its effect on the rays could be calculated in ways very similar to those by means of which the direction of light rays through glass lenses were calculated. Thus

electrostatic focusing and electromagnetic focusing (for the magnetic effect could be subjected to similar electron-optical calculations) were possible. The limitation of the gas-focused cathode-ray tube was thus removed, for a hard-vacuum tube with accurate focusing could be made.

It is thus seen that 1932 was really the crucial year for modern developments in cathode-ray tubes, and, as has been said before, the G.E.C. was in production by 1934. In 1936 it produced the first tube with a screen diameter of only 1 inch, a small C.R.T. very suitable for monitoring, i.e. for insertion in a control circuit to show visually any condition that the controller needed to know. Other firms have similar records in producing the 'first' tube of this or that characteristic. Refinements in techniques have led to a great advance in the reliability and range of types of cathode-ray tube, a development accelerated during the war by the need for special sorts of C.R.T. for radar.

Despite all these advances, the manufacture of cathode-ray tubes in peacetime would have remained an important but fairly small industry limited to the supply of tubes for engineers and scientists had it not been for a revolutionary invention made by V. K. Zworykin (U.S.A.) in 1934. By this invention all mechanical methods of scanning were rendered obsolete for television, which now became really possible for large-scale entertainment. Zworykin, familiar with the work of earlier men such as the Russian Boris Rosing and the Englishman Campbell Swinton, improved on their ideas and produced a modified cathode-ray tube for transforming a viewed scene into a succession of electrical changes. This brought with it the increased possibility of the use of a synchronised cathode-ray tube for receiving the transmitted electrical changes. The production of cathode-ray tubes in peacetime thus became a matter of wide interest to industrialists. Every viewer today sees his picture on the fluorescent screen of a cathode-ray tube, the essentials of which have been known for more than half a century and which has been made here and there by individual experimenters during the whole of that period, but which has been in commercial production for barely twenty years.

Clear Air Turbulence: A Menace to High-flying Aircraft

AMONG the problems raised by the advent of jet-propelled aircraft is that of turbulence encountered in clear air (which means that the pilot gets no warning of the occurrence of such turbulence) at the high altitudes necessary to get the best return from jet propulsion. This can affect not only comfort, but also the safety of the aircraft. For both reasons, Mr. N. E. Rowe, who is controller of Research and Special Developments to British European Airways, suggested to the Ministry of Supply in 1946 that research project should be undertaken, and that this should be directed and operated by the airline. This was agreed, and two Mosquito aircraft were placed at his disposal. Between January, 1948 and January 1950 a total of 92,286 miles was flown by these planes, mostly within the area bounded by Stockholm, Edinburgh, Lisbon and Rome. The flight plan was to follow a vertical sawtooth, with the aircraft alternately climbing and descending—in some flights between 37,000 ft. and 20,000 ft., and in others between 35,000 ft. and 15,000 ft. Vertical acceleration was recorded with an instrument in which the measured quantity is the movement of a weight suspended from a spring. The results have been described lately by Dr. G. S. Hislop at a joint meeting of the Royal Aeronautical Society and the Royal Meteorological Society.

The sensation, according to one pilot, is like "being in a fast car suddenly running over a series of deep unseen ruts in a road". The turbulence that gives this effect was found in isolated patches which, typically, are 50–100 miles long and about 3000 ft. thick. Twenty such patches were found, and of these 10 were within 2000 ft. of the tropopause*—although as a boundary region of constant temperature, it would be expected that this would be free from vertical wind gradients. On the average, and lumping together the results for all heights investigated, it was necessary to fly about 5000 miles to encounter a change in vertical acceleration equal to one-quarter or more that of gravity at ground level, and some 20,000 miles for a vertical acceleration equal to half-gravity. The greatest acceleration recorded was 70% that of gravity. This must have approached in magnitude the 'clear air turbulence' which the Comet aircraft encountered on its early development trials. It is concluded that the Comet episode cannot be dismissed as a freak, and that gusts of still greater severity may be expected as rare occurrences.

Another question affecting the designer is the possibility that resonance might be established between the frequency of successive bumps and the natural frequency of wing vibration of the aircraft. In this connexion, it was noticed that the frequency of bumping in a turbulent patch may remain roughly constant for several seconds, and with an aircraft that is flying at 350 m.p.h., this may reach a frequency of 3 bumps per second. Dr. Hislop pointed out that this would be the natural frequency of wing vibration for an aircraft with 130 ft. wing span.

On the meteorological side, 'clear air turbulence' was found to be associated with temperature variation in a horizontal direction, which would correspond with high wind gradients vertically. A condition which meets these specifications is the so-called 'jet stream', defined as a narrow belt of high wind, of 100 knots or greater, embedded in an air stream of markedly lower velocity. It is thought possible that the most severe cases of turbulence may be due to jet streams of this kind, although the evidence for this is rather limited. Another pointer is that all but three of the turbulent areas encountered were connected with areas of low pressure, although some of these were very shallow and might be dismissed as insignificant. The outlook for a forecasting service is, therefore, somewhat uncertain at the present time. Advice to air-crews includes the following points: avoid flying in areas where there are known to be jet streams, or where there are marked variations in horizontal temperature; avoid flying within 2000 ft. of the tropopause; if heavy turbulence is encountered, either climb or descend, or fly at right angles to the local wind direction; and last, if there is any sign of wing vibration being excited by turbulence, alter speed as much as possible, preferably by accelerating.

* There are two shells of air surrounding the earth; the *troposphere* (which is near the earth) and the *stratosphere*. The thickness of the troposphere varies from about 11 miles near the equator to 6 miles near the poles. The boundary between the shells is the *tropopause*.

Achatina's Odyssey

RAVAGES OF A GLOBE-TROTTING SNAIL

DR. W. J. REES

British Museum (Natural History), South Kensington.

THE Giant African Snail is a serious pest of cultivated vegetables, flowers, and fruits in all countries to which it has been introduced. It has recently become headline news in the United States which is the latest country to become aware of this uninvited guest. During the past 150 years it has found its way across the Pacific and has invaded many tropical and semi-tropical countries, including several British dominions and colonies, where its control has become a difficult problem. Some account of the animal, its history, habits, and control, may help to present a balanced picture of the pest.

Achatina fulica, as it is known to the biologist, has a shell 5 in. in length, a body of about 10 in., and a weight of half a pound. It has an appetite in keeping with its size, and although mainly a scavenger, attacks living plants, particularly seedlings, flowering plants, vegetables, ornamental shrubs, and fruit trees (leaves, flowers, and fruit). In its original East African home the snail is no pest, probably because its numbers are kept down by natural enemies, but in new environments it breeds rapidly and unchecked by old enemies, so that the snail population reaches phenomenal proportions capable of great damage to plant life.

The history of the spread of *Achatina* eastwards across the Indo-Pacific is without parallel in the dispersal of snails. It is generally believed that the snail reached Mauritius from East Africa or Madagascar about 1800, and was common when the French naturalist Bosc visited the island in 1803. Soon it spread to the Seychelles and to Réunion. From Mauritius it was taken to Calcutta by the conchologist, W. H. Benson, in 1847, and by 1876–7 it was firmly established in and around the suburbs. Later, in 1907, it was reported to have spread all over Northern Bengal.

Yet another conchologist, Oliver Collett, introduced it to Ceylon in 1900. Here the first really big outbreak occurred in 1910 in the Kalatura district. The Government entomologist in his official report stated:

The huge snails were to be seen—literally in millions—crawling over the ground, climbing up walls, fences, and poles, and clustered upon the trunks of trees. Some 227 snails were counted in one such cluster on the stem of a coconut tree in a length of about 6 ft. Many other large clusters were observed. They congregated in a similar manner on the tops of fence poles (usually living stems of *Jatropha*) erected round young coconut plants. The ground beneath the clusters was covered an inch deep with the excreta of the snails.

This kind of plague has been repeated over and over again in other countries.

Ceylon to California

There are conflicting reports about the date of its arrival in Malaya, and whether it got to Singapore or to Kedah first. It may have been as early as 1911 or as late as 1920. The earlier date appears the more likely so far as Singapore is concerned, and in the absence of other evidence botanical plants from Calcutta are the most probable source. The widespread dispersal of the snail in the Malay States was facilitated by horticultural shows, and by the Chinese population who encouraged the propagation of the snail for use as duck food in a crushed condition.

Singapore proved to be a wonderful centre for dispersing the pest farther afield to Sarawak (1928), Sumatra (1930) Amoy Island (1931); Java (1933), Siam, Hanoi, and Hongkong (1936–7). The local Chinese population in Malaya must be held responsible for spreading *Achatina* to some of these places for use as duck food. This was how the snail reached Kuching in Sarawak in 1928. By 1930 it had become a serious problem, and in the autumn of the following year a reward was offered for the snails and their eggs. In a fortnight 500,000 snails and 20 million eggs were destroyed with no appreciable diminution of the numbers still remaining.

At Hongkong the snail was first discovered in 1941 when it was found well established in the Sookunpoo and Happy Valleys. Specimens of all ages, up to adults about four years old, were present, and it was concluded that the original importation took place about 1937. During the Japanese occupation the snail population multiplied without check. Dr. Herklots gives a figure of 153,693 snails (weighing 10,603 lb.) collected by the staff or the gardens department in 1947. There is no doubt that figure would be much higher if the snail was not forced to be inactive and hibernate during the dry, cold winter months from November to April.

When the Japanese took a hand in the spreading of *Achatina*, or where they obtained it, is not certain. Before the war they maintained fishing colonies at Singapore and Hongkong, and there is evidence that they took an interest in the snail as a source of food; some reports indicate that they consider *Achatina* stew a great delicacy. Be that as it may, they are known to have taken it to Formosa and the Japanese mainland before 1936, and also to some of their mandated Pacific Islands before 1940.

From Japanese territory the snail reached Hawaii by post in 1936, where it was farmed as a delicacy by a Japanese settler in the island of Maui. Soon, but not soon enough, the agricultural authorities learned of its presence and attempted to destroy every specimen by a costly campaign. In the same year a Hawaiian woman brought two snails from Formosa to the island of Oahu. Here the pest was quickly beyond control. In the meantime there was another outbreak on Maui, this time too big to eradicate. So far, during a period of 10 years, the Hawaiian authorities have spent £30,000 in trying to wipe out *Achatina*, but the snail population is still on the increase and it is now realised that eradication is impossible. They have, however, been able to restrict the snail to the two islands.

During their rapid conquest of the Pacific, the Japanese armed forces carried *Achatina* with them southwards, introducing it to many islands, including New Guinea, New Britain, and New Ireland. In all these it is spreading and

The Giant African Snail seen alongside the common garden snail.

multiplying at an alarming rate. By 1946 it had spread over large areas of New Britain and New Ireland, while in the Madang area of New Guinea it was penetrating into the bush.

The latest port of call for *Achatina* is San Pedro, California, where it was introduced with salved war equipment brought back from the Pacific Islands. They were found in thousands, clinging or buried in caked mud, on the underside of vehicles, and had begun to make homes for themselves in the proximity of the wharves. The Californian authorities were quickly alive to the problem and eradication is believed to be complete. Scientists in the United States are, however, greatly concerned about the possible entry of the snail through Atlantic coast ports, where there are no regulations prohibiting the introduction of contaminated war equipment.

Lemon–Yellow Eggs

The secret of *Achatina's* rapid multiplication lies in its biologically efficient method of reproduction. Each snail (which is hermaphrodite) can lay 50–300 eggs every two or three months from one year old, and may continue to do this for five years or more. The lemon-yellow eggs are about the size of dried peas and are covered with a thin shell. They are laid in loose pockets of soil or even on the surface of damp, shady undergrowth. Hatching may be over in a few days and growth is rapid in favourable circumstances. By day the young (and even the adult) prefer to remain under cover, feeding actively only by night. This makes detection and eradication difficult during the early stages of the attack when control might be possible. Under dry conditions the snail hides in the soil and secretes a thin cover over the mouth of its shell. It can aestivate for several months until the wet weather comes again.

All these features in the life of *Achatina* make it a difficult pest to control. Some of the methods employed to gain temporary relief may be mentioned. *Achatina* must have lime to build its shell, and in countries where lime is deficient in the soil some use of this factor has been made. In Ceylon, for instance, there is a lime deficiency and the snails eat limewash on walls and wherever they can find it. Limewash with a small admixture of calcium arsenite is effective, so are baits containing metaldehyde, for keeping down the number of snails. *Achatina* is to some extent cannibalistic, and a crushed snail will attract others to feast on it; these in turn can be crushed to lure still other snails. The clearing of rubbish heaps and the destruction of garbage, in and around native villages, is sound policy so far as small gardens are concerned, as it reduces the amount of food available. The leaves, flowers, and fruit of trees can be protected with tarred bands fixed around the stems.

All these are but preventive measures, and the search for some biological means of control still continues. In Calcutta during the early part of this century it was noticed that in some years *Achatina* was subject to some epidemic which killed off thousands, but the nature of the disease is still unknown. It is acknowledged that the pest is not multiplying at such an alarming rate as in earlier years in Ceylon; this may be because the larva of the Indian Glowworm (*Lamprophorus*) has acquired a taste for the snail. One female larva can account for 30 to 40 snails during its development.

The National Research Council of the United States sent a scientist to Africa to seek natural enemies of *Achatina*. He found that a small carnivorous snail of the genus *Goniaxis* and a beetle of the genus *Tefflus* preyed on the giant snail in its native haunts. Biological control is, however, in its infancy, and the American authorities are reluctant to release these natural enemies in the Pacific islands, because in the long run they might wipe out all the native snail fauna and perhaps become worse pests than *Achatina*.

Australia is free from attack so far, and although the Australian authorities are alive to the possibility of the introduction of the pest from New Guinea, the utmost vigilance will be required to keep it out. Recent experiments carried out at the British Museum (Natural History) indicate that Britain has too cold a climate for *Achatina* to survive, for it needs a minimum temperature of about 75° F. for it to remain active and breeding. Recently much more information has become available on the natural enemies of *Achatina* as a result of researches conducted in East Africa by Dr. Frances X. Williams on behalf of the Pacific Science Board of the National Research Council of the United States. The search for predators for possible use in combating the snail in the Pacific islands was very successful, and, among the natural enemies of *Achatina*, Williams mentions *Bdeogaoe genius* (a mongoose-like animal of the civet cat family), land crabs in coastal areas, carnivorous mollusca of the family *Streptaxidae* and a number of insects.

Insect predators included beetles of the genus *Tefflus* and the larvae of the family *Drillidae*. Williams regards the molluscs *Edentulina affinis* and *Gonaxis kibweziensis* as probably the most effective enemies of *Achatina* in East Africa and information from other sources indicates that a small scale experiment in control is being tried with one of these snails on a small Pacific island.

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A valuable paper by Dr. Rees on the Giant African Snail will be found in *Proc. Zool. Soc. Lond.*, Vol. 120, Pt. III, pp. 577–598.

A GREAT deal of publicity has been given to Habakkuk—the unsinkable aircraft carrier which was to be made out of reinforced ice. That publicity was misleading in that it created the impression that Habakkuk was a practical proposition, whereas in fact it belonged to the realms of fantasy—it is probably no accident that something very like Habakkuk was brought into George Orwell's futuristic novel, "1984". In order to keep our records of wartime research and invention straight, we print this article by Sir Charles Goodeve, who was Assistant Controller for Research and Development at the Admiralty during World War II. It is published by permission of the editor of the *Evening Standard*.

The Ice Ship Fiasco

SIR CHARLES GOODEVE, F.R.S.*

ONCE during the war an inventor brought forward the novel idea of a searchlight that would itself bring down any aircraft caught in its beam. The idea was to provide the searchlight with a button which when pressed would solidify the beam. By rapidly turning the searchlight downwards, one could 'wang' the aircraft on the ground.

The incidental details as to how to solidify the beam were, according to the inventor, "merely matters of research and development easily solvable by anyone who really believed in the idea".

Many inventions of varying degree of absurdity, as well as some useful ones were put forward during the war, but none produced a dislocation of the Allied effort to a fraction of the extent achieved by 'Habakkuk', a proposal put forward by Geoffrey Pyke. He himself named this grandiose scheme after the prophet who said: "I will work a work in your days which ye will not believe, though it be told you."

New 'Weapon'

Wars had for long been fought with steel and explosives, and more recently with aluminium and electrons. To these was now to be added a new element of war, ICE.

"Ice," it was pointed out, "was plentiful and didn't sink. Let us build large unsinkable aircraft carriers of ice and thus provide air cover for an attack on a remote and unprotected part of France. Steel limits the size of our carriers to tens of thousands of tons; with ice we can throw off our shackles and build carriers of millions of tons each.

"Ice is plentiful! Ice is unsinkable! Ice is hard! The enemy will never suspect it! *Ice will win the war!*"

At first the scientists and engineers working on their radar, their jet-propulsion, their tank-landing craft and the thousand and one other developments which were to be put in the hands of our fighting men, laughed. Ice may be hard, but it had no strength.

Their laughter turned to alarm when they learned of the long-haired scientists, the admirals and generals who had been swayed by the magnetic personality of the inventor.

Here was no ordinary man; this was no ordinary way to win a war.

One scientist showed that the wave-functions of the hydrogen atoms in ice bore a close relation to those in concrete, and therefore it should be possible to make ice as strong as concrete (forgetting, of course, that concrete has little strength other than that of its steel reinforcement).

An engineer who had already built an air-raid shelter offered to build the first Habakkuk.

Pyke put it to Lord Mountbatten, Chief of Combined Operations, on whose staff he was; Mountbatten passed it to the Chiefs of Staff who passed it to the War Cabinet, the War Cabinet to Churchill.

Winston, an inventor of no mean repute himself, wrote: "Let us cut a large chunk of ice from the Arctic ice-cap and tow it down past Cornwall, fly on our aircraft, and tow it to the point of attack." Pyke's followers were triumphant. "Churchill approves! The war will be won by ice! All that is left are merely matters of research and development easily solvable by anyone who really believes."

Orders flew thick and fast, committees were set up. The voices of reason were shouted down by cries of "obstruction".

These in control of important war programmes had the Hobson's Choice of either fighting this absurdity or of ignoring it as far as possible, the objective in either case being to confine the dislocation of effort.

This Fantasy

Their success was indifferent. At one stage they thought it would be a good idea to send the whole party to Canada, where the winter might cool its ardour. The Canadians were sensible people; they would get this monstrous fantasy under control. But ahead of the team went this message: "This was Canada's opportunity to play a part in history!"

Far up in the Rocky Mountains a lake was chosen. In great secrecy a camp was built and an experimental model was constructed. Hundreds of skilled designers were put to work all over the country designing refrigerating plant, remotely operated electric propulsion motors, etc., they knew not for what. Came the spring, and with it one conclusion from the trials; *ice melts*.

Once again the voices of reason could be heard. "Ice has no strength, ice melts, ice is cold, the steel required to hold the ice together, to build the refrigerating plant, the propulsion machinery was far more than would be required to build conventional aircraft carriers of much more effective fighting power.

"Conventional?" you say. Have you no imagination? Ice is the new element of war.

All would have been well if it hadn't happened that at this moment one of the many parties detailed off for research into the problems of Habakkuk discovered that ice could be given some strength by incorporating a large amount of paper-making pulp in the water before freezing.

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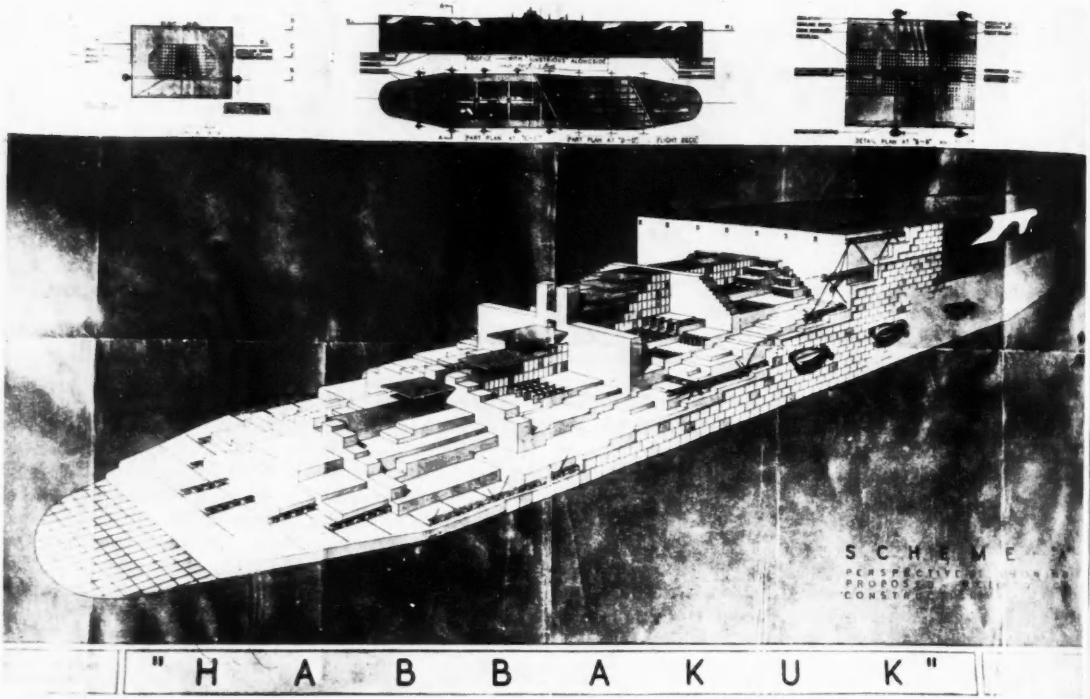

This cut-away section shows the design which was proposed for "Habakkuk", the iceberg aircraft carrier which was intended to replace aircraft carriers of the size of H.M.S. *Illustrious*.

Just Six Knots

The frozen block did not yield easily to the hatchet, and a bullet fired at it went in so smoothly that the ice reformed behind it. The followers were elated and called this material Pykrete in honour of their leader.

"Pykrete," they said, "is not only unsinkable, but it is self-healing against bullets, bombs and torpedoes! Never mind if we have to reduce all the allied newspapers to letter size. We've proved that research will solve all our problems if the obstructors can only be got out of the way."

Designs and plans for construction were rushed ahead. Each Habakkuk required 40,000 tons of cork insulation, some thousands of miles of steel tubing for brine circulation and reinforcement, four power stations, and endless additional complications, especially in the building stage, even before you started making it into an aircraft carrier.

At that, the maximum speed would only be six knots. (By leaving the ice out and converting the tubing to ship's plates the whole would have been able to go four times as fast.)

But there was one obstacle that even research and faith could not overcome: Great Britain hadn't the resources to build even one Habakkuk.

However, armed with blocks of Pykrete, a revolver and plenty of rounds of ammunition, and wave-mechanical equations of hydrogen atoms, the team descended on the Quebec Conference, held to decide on the plan of attack on the European continent.

Fortunately, a decision was made not to wait for Habakkuk, but to rely on the daring, but sound, scheme which became known as the Mulberry Harbour. Nevertheless, this conference of the heads of the three great States, U.K., U.S.A. and Canada, together with their Chiefs of Staff, decided that a Habakkuk should be built under the supervision of an Anglo-American-Canadian committee with a secretariat in the U.S. Navy Offices in Washington.

But at such high altitudes came a new discovery. Not only does ice melt, but it evaporates! and so did Habakkuk.

The great three-power committee never was convened. The followers became dispersed or else cooked in the heat of Washington.

THIS article is the first of a series dealing with Russian contributions to science. The series is designed to give a clear picture of the work of Russian scientists, but readers will appreciate the difficulties that stand in the way of clear vision and that arise because of the propaganda cloud which befogs everything Russian, and we trust that due allowance will be made for this factor. Eric Ashby has studied Russian botany at first hand: during the last war he was scientific liaison officer in Moscow for the Australian Government. In that capacity he had a unique opportunity to get to know Russian botanists and to see their researches in progress. Some of those wartime experiences he has already described in the book *Scientist in Russia*, published by Penguin Books in 1947.

Science in Russia—I

THE CONTRIBUTIONS OF RUSSIAN BOTANISTS

ERIC ASHBY

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THE nineteenth century was a golden age for Russian literature. It was a sudden and splendid flowering, all the more remarkable because it seemed to have no roots. An Englishman, whose poetry begins with Chaucer, finds it hard to realise that Russian poetry virtually begins with Krylov, who died in 1884. And with Russian science there is a similar situation. In the late sixteenth century Boris Godunov sent a handful of young Russians to study in the West, but they never returned to Russia; it was not until the end of the seventeenth century that the elements of Euclid were first taught in the navigation school provided by Peter the Great; and—owing to the absence of universities—the beginnings of scientific work in Russia date from the foundation of the Academy of Sciences in 1725. The Academy was for many years under predominantly German influence and another 150 years passed before it became a genuinely Russian institution.

So Russian botany, like Russian literature, has its roots just beneath the surface of the contemporary scene. There were famous botanists in the nineteenth century, but the main accomplishments of Russian botany lie in the present century, and, indeed, lie mostly within the brief and turbulent history of Russia since the Revolution.

Familiar are the names of Timiryazev (1843–1920), who laid some of the foundations of plant physiology; Kostytschev (1877–1931) who is said to have coined the word *anaerobic* for respiration in the absence of oxygen; Palladin (1859–1922), whose early work on plant biochemistry has a permanent place in botanical history; and Maximov who, at the age of 71, is now preparing a second edition to his unique book *The Plant in Relation to Water*. It is interesting that these are all the names of physiologists: it was the experimental botany of nineteenth-century Germany, rather than German anatomy and morphology, which appealed to the young Russian students who were able to study there.

Contemporary Russian botany has its origin in the work of these pioneers, and its contribution to world science is acknowledged with great respect. But the work of living botanists is inspired largely by the enthusiasms and demands of the Soviet state. To be familiar with natural resources and to conduct a successful struggle against Nature are two of the axioms that inspire Soviet policy. Accordingly, such activities as the efforts to compile a Flora of the U.S.S.R., to produce vegetation maps, to study frost resistance and drought resistance, and control of flowering and fruiting, are the natural outcome of state planning.

The compilation of the Flora of the U.S.S.R. is entrusted to the Botanical Institute in Leningrad. This dates from the time of Peter the Great, and houses a herbarium, which is said to contain about five million species—three-quarters of the world's flora. From this institute between the years 1841–53 there came the *Flora rossica*, and now its staff has nearly completed a new Flora of twenty-four volumes. The work is carried out by a team of forty workers and was directed by the distinguished botanist Komarov, until his death five years ago.

The preparation of this Flora is an example of the sort of research in which modern Russia excels. The work does not require brilliant originality or ingenious techniques; it does require well-organised team work and liberal facilities for exploration under difficult conditions. The plant-hunting expeditions which the work has involved have been exciting and it is interesting to find that the classification of plants, which is regarded by most botany students in Britain as an irksome, if necessary, drudgery, is regarded by many Soviet botany students as the most thrilling career open to them.

The plant-hunting expeditions have not only collected and named plants: they have also classified and mapped vegetation, and a second accomplishment of the Komarov Botanical Institute (as it is now called) is to produce a vegetation map of the whole of the Soviet Union on a scale 1–5 million under the direction of Lavrenko. This also is the product of team work, and it is a model of its kind. Accompanying this work are numerous intensive studies of the vegetation of small areas, particularly those of interest to farmers. These studies are published from the institute in a series of monographs called *Geobotanika*.

Not only in Leningrad, but also in other parts of Russia, plant geography flourishes. In Repetek, for instance, Petrov has made some interesting studies on the binding of sand dunes by plants, and at the Institute of Fodders near Moscow, Ramensky has devised ingenious methods for mapping the distribution of different sorts of pasture grasses. There is even a special professorship of plant geography in Moscow, held by Aleuchin, who has

published interesting historical maps which show the changes in vegetation which have accompanied agricultural settlement.

All these contributions to botany are rather of domestic interest to the Russians than of general interest to the botanical world, because they have been done on conventional lines and they have not introduced fresh concepts into botany. With experimental botany in Russia it is quite otherwise: to Russian botanists is due the credit—and in some instances the notoriety—for opening up several fresh fields of inquiry. Most familiar to British students is the work of Maximov and his school on drought resistance in plants. It was formerly believed that plants are able to live in deserts by virtue of the fact that they are economical with their water supply, and possess all sorts of morphological devices for minimising water loss: leaves reduced to needles or absent altogether, thick coatings of wax, and so on. Maximov played a decisive part in demonstrating that this plausible belief is incorrect. Many plants live in deserts because they are able to *endure drought*, not because they *avoid desiccation* by conserving their water supply. This discovery put into a new perspective the problem of plant life in deserts: drought resistance is now regarded as a property of the individual plant cell, not a characteristic of the whole plant, explicable from an inspection of its appearance. And about six years ago Maximov published an important paper in which he demonstrated that the ability of a cell to withstand drying is dependent upon the viscosity of its protoplasm. The secret of life in deserts has become a problem in biophysics.

Another field of experimental botany to which the Russians have made important contributions is the control of flowering. This is a subject which has been intensively studied in the United States and Germany. The basic discovery, upon which all subsequent research rests, is that many plants are brought into flower after exposure to a specific *length of day*. The effect of length of day is not due to the intensity of the light—a very dim light is sufficient to affect flowering, nor is it due to temperature—though temperature changes do affect the operation of length of day. It seems that some kind of flower-forming hormone is produced when the day reaches an appropriate length. To take an example at random, Morning-Glory (*Ipomoea*) flowers in three weeks from the seedling stage if it is given eight hours of light every day; it does not flower for twelve weeks if it is given sixteen hours of light every twenty-four hours.

The contribution which the Russians have made to this fascinating problem comes from two laboratories: that of Chailachjan in Moscow, and Moshkov in Leningrad. These men, by a series of brilliantly executed experiments, have proved that it is the *leaf* of a plant which "perceives" the length of day and from which is transmitted the hormone to the stem and up to the flower bud. Furthermore they have shown that one single leaf is enough to "perceive" the day-length—indeed with the correct length of day a quarter of a leaf is enough to bring about flowering. They have also shown that day-length affects not only flowering but other characteristics of the plant such as frost-resistance, which in willows is greater in short days than in long days, and leaf-fall.

Another field of experimental botany to which the Russians have made contributions is the study of growth hormones. The effects of the hormone known as *auxin* on the growth of stems have been intensively studied in most Western countries. It has long been known that the very same material which stimulates stem-growth, does, in the same concentration, suppress root-growth. A botanist from the Ukraine, Cholodny, has made the most important contributions to our understanding of the effects of auxin on root growth. He finds that roots are more sensitive to the hormone than stems, and are stimulated by much smaller amounts of it.

There is space to mention only one more major contribution which Russia has made to botany. This is the work of Krenke, who died in 1940. Krenke was interested in the diagnosis of rate of ageing in plants and in the discrimination of physiological age from time-age: a major unsolved problem in biology and one now popularised by the unsightly name of gerontology. Krenke asserted that perennial plants went through cycles of ageing and rejuvenation and that the progress of the cycles could be diagnosed from a study of the shapes of leaves produced by the plants. Recent research in this country shows that the story is not nearly so simple as Krenke supposed it to be, but Krenke's idea that there are cycles of ageing and rejuvenation has been confirmed for one particular plant, the common duckweed (*Lemna*), and in formulating this idea Krenke certainly made a major contribution to world botany.

I have confined myself to a summary of some of the positive contributions made by Russians to modern botany. Unfortunately not all the contributions have been positive; some have set back the clock because they do not abide by the canons of scientific criticism which are accepted by the rest of the civilised world. In this category are the emphatic assertions about the higher yields which follow bacterial treatment of seeds, and the propaganda (which has almost become a myth) about success in the agricultural applications of vernalisation; and, of course, the fantastic rodomontades about genetics. In other countries such opinions as these would never get into print: nor would they in Russia if the scientists there had their way. It is unfortunate that in recent years the nonsense of Russian botany has received far more publicity than the good sense that it contains.

FIG. 1.—Waterloo Bridge, a fine example of reinforced-concrete construction. Designed by Rendel, Palmer and Tritton in association with Sir Pierson Frank, Chief Engineer to the London County Council, it was completed in 1942. The architect was Sir Giles Gilbert Scott.

Developments in Concrete

N. N. B. ORDMAN, B.Sc., A.M.Inst.C.E.

'JETS', 'rockets' and 'radar' are words that are thoroughly familiar to the general public. Spotlighted by the needs of war, these developments have received a measure of publicity entirely unaccorded to a peacetime development in civil engineering which, even if it is not so spectacular, is, in many other ways, as important. This development is known as 'Pre-stressed Concrete'.

Invented by the famous French engineer Eugene Freyssinet some thirty or forty years ago, only now are its full implications being realised.

The conglomeration of stones, sand, cement and water which sets to the rock-like consistency of concrete is well known. Concrete is by no means a new material; it was used, for instance, by the Greeks and the Etruscans. In fact, the dome of the Pantheon, with its span of 142½ ft. was built by those great engineers, the Romans, in solid concrete. Actually the Romans knew as much about concrete as did anyone until the middle of the nineteenth century. It was then that the forerunner of our modern Portland cement was invented in this country by Isaac C. Johnson. Since then, constant research has brought about many improvements which have resulted in wider and ever more scientific uses of concrete, until today there is hardly a structure in the civilised world which does not incorporate it in one form or another.

But concrete in its plain form has an important weakness that had to be overcome before the most important modern advances could be made. 'Pre-stressing' is the latest advance, but before explaining the principles and technique of this it will be necessary to make clear where the weakness of concrete lies and what methods have been used hitherto to overcome it.

Ordinary concrete is strong in its resistance to compression (i.e. crushing), but only about one-tenth as strong in its resistance to tension (i.e. stretching). This statement may be clearly illustrated by considering the effect of placing a load on a simple beam. As illustrated in Fig. 2*a*, such a beam (e.g. a floor beam or the deck beam of a

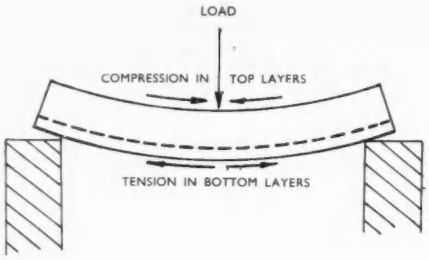


FIG. 2*a*.—A simple beam is shown bending due to a load centrally applied, illustrating the compression which occurs in the top layers, and the stretching (or tension) in the bottom layers. The dotted line indicates reinforcing bars embedded in the concrete in the tensile zone.

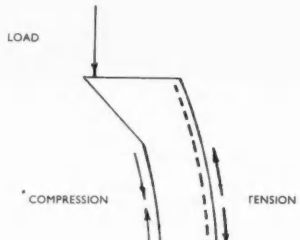


FIG. 2*b*.—Column with the load applied off centre, shown bending with compression on the inside layers, and tension on the outside layers. The dotted lines indicates steel reinforcing bars embedded in the concrete in the tensile zone.

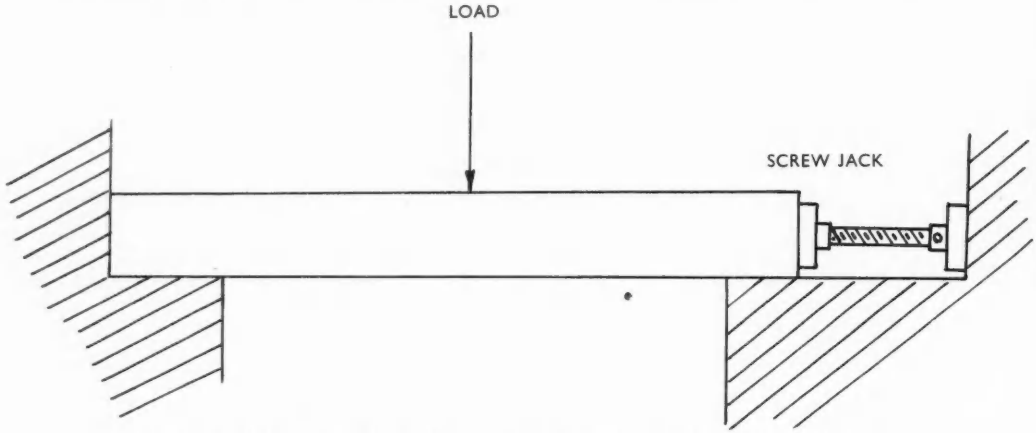


FIG. 3.—Simple type of "pre-stressed" beam. The sag in the beam which would normally occur under the load is removed by the application of compression by means of a jack placed between the end of the beam and the supporting side wall.

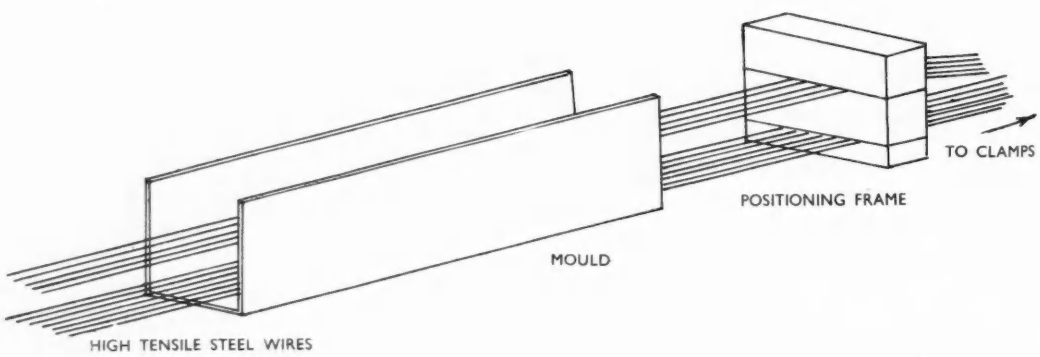


FIG. 4.—Diagrammatic view illustrating a simple pre-tensioning system. The high tensile steel wires are shown after they have been tensioned prior to the concrete being poured. They are held in position by frames and secured by clamps.

bridge) when subject to simple loading tends to sag in the middle. The bottom layers of the material are stretched —that is, they are subjected to 'tensile' stresses—and the top layers are compressed. Another example (Fig. 2*b*) is a simple column with the load applied off-centre. (Both illustrations are exaggerated to show the bending more clearly). The concrete being ten times as strong in compression as it is in tension, it will invariably fail by cracking in the stretched layers (those subjected to tension) long before its full compressive strength has been developed in the compressed layers.

The use of concrete right up to the nineteenth century was restricted mainly because it could not be used economically in those parts of a structure where tension occurred. To overcome this weakness concrete has to rely on the assistance of steel, which is strong both in compression and tension. The technique of reinforced concrete is to introduce steel bars to withstand the tensile stresses, and in the simple example we have taken steel bars would be embedded in the tensile zone of the beam or column while it was being cast as illustrated by the dotted lines in Figs. 2*a* and 2*b*.

Reinforced concrete (it is also called ferro-concrete), which owes its invention and early development to the French, was first used by Joseph Monier in the second half of the nineteenth century. Monier, a French gardener, took out many patents for reinforced concrete structures; one of them was for a concrete coffin! In 1850, Francois Coignet built a house at St. Denis near Paris which had a reinforced concrete roof with a 23½ ft. span.

Francois Hennebique was a great pioneer at the turn of the century and other famous French engineers who developed the design and technique of reinforced concrete were Rabut, Considere and Mouchel. The latter was responsible for the first reinforced concrete structures in Britain; these were the river walls founded on reinforced concrete piles at Southampton and Swansea, and also a flour mill at Swansea built in 1897.

This technique, which became elaborated to an enormous degree, is the basis of a multitude of reinforced concrete structures, the most spectacular of which, and the best known, are bridges. A fine example is the new Waterloo Bridge over the Thames, completed in 1942 (Fig. 1). A very beautiful example of a reinforced concrete arched bridge is the Aare Bridge in Switzerland (Fig. 6).

'Pre-stressed Concrete', which is also a composite material of steel and concrete, has an importance so far-reaching that its full application may well revolutionise concrete technology. This development is almost entirely due to one man, the contemporary French engineer Eugene Freyssinet, and has occurred within the last quarter of century.

The basic principle of pre-stressed concrete is by no means novel. It consists essentially of applying to the concrete member *before it is subjected to load* sufficient compression to enable it to balance the tension stresses which will be set up when the load is applied. A simple illustration of this principle is as follows: lift up half a dozen books by placing one hand against the cover of each outside book and pressing the books together; the books are thus rendered sufficiently rigid and 'homogeneous' by this external pressure to enable them to be lifted together as a unit, and if a weight is placed on the centre of the 'book beam' it will be quite readily supported provided that the external pressure is maintained, although the books have no inherent structural strength apart from the ability to resist the applied pressure without being crushed.

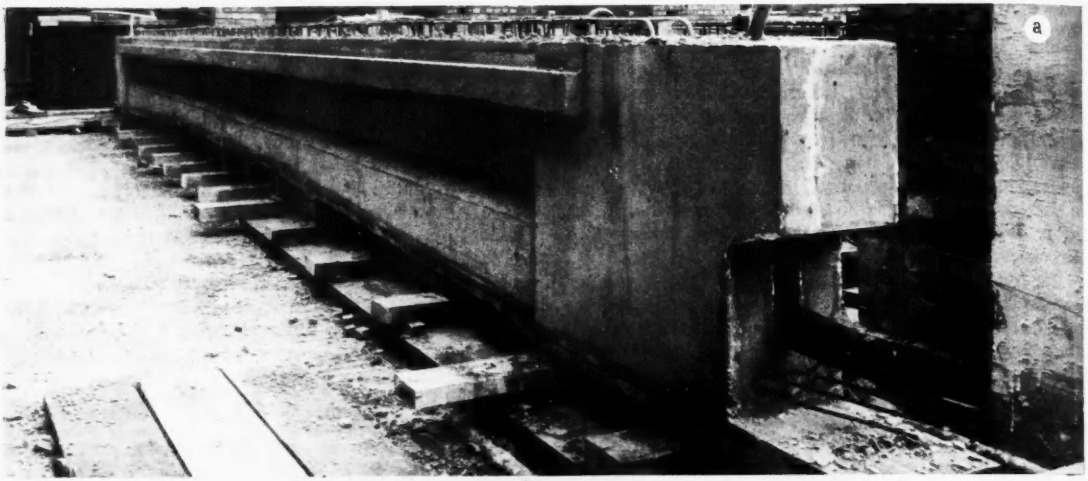
The principle is readily applicable to concrete. Reverting to the beam illustrated in Fig. 2*a*, the sag in the beam, and hence the tension in the lower layers, could be removed by applying compression by means of a jack at one end (Fig. 3). If the compression applied is equal to the tension in the bottom of the beam it will neutralise it. The steel bars in the bottom will not then be required. The compression in the top will be doubled, but as concrete is strong in compression, this double compression can be sustained. In fact, by making the concrete sustain a high compressive stress and relieving it of tension, the material is being used in accordance with its natural characteristics and thus economically. This is an elementary example of pre-stressed concrete.

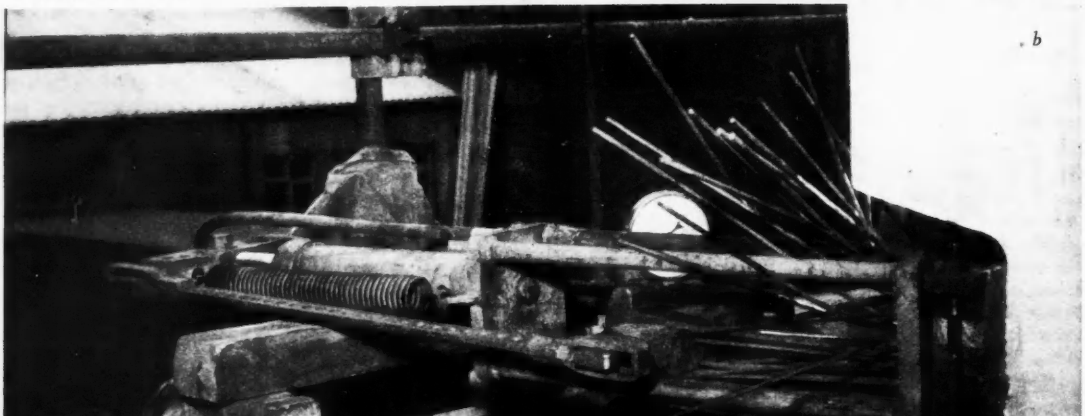
Although the simple method of applying 'pre-stress' by means of a system of jacks has been used in practice, this is not a normal method of application. Two main techniques are employed, both of which are extremely ingenious. They are both still in the process of development.

The first technique is known as 'pre-tensioning', and is particularly applicable to prefabricated beams. In this method, illustrated in Fig. 4, the mould is set up on a bench and high tensile steel wires (rather like piano wires) are laid in it. These wires are then stretched apart by powerful jacks to a predetermined extension and clamped in position. The concrete is poured into the mould and allowed to harden. The wires are then released from the clamps. They are restrained from returning to their normal state by the hardened concrete, and in obedience to the natural law they apply a compressive strain and hence stress to the concrete: in other words they apply 'pre-stress' to the beam.

The second technique is known as 'post-tensioning' and is mainly used in work actually carried out on the building site. The beam, which is cast either on the site or elsewhere, contains longitudinal holes formed by cardboard tubes, rubber sheaths, or some other means. High-tensile steel wires are then threaded through the length of the beam and clamped at one end. A jack is attached to the other end of the wires, and by jacking against the end of the beam the wires are stretched to a predetermined length and clamped in position. The ends of the wires projecting beyond the clamp are trimmed off, and the clamps at each end of the beam are concreted up. The stretched wires, in attempting to return to their normal state, apply the 'pre-stress', as in the case of the pre-tensioned beam described in the previous paragraph. A pre-stressed beam of this type is illustrated in Fig. 5. Fig. 5*a* illustrates the beam prior to the stretching of the wires. Fig. 5*b* shows a hydraulic jack tensioning the wires, and Fig. 5*c* shows the wires clamped in position. The wires are then trimmed off and the clamps concreted up. The particular method of post-tensioning illustrated here is called the 'Magnel-Blaton' system. The beam illustrated here is one of a number recently used in the construction of a new department at Queen Mary's College, London.

Much ingenuity has been exercised by M. Freyssinet and Professor Magnel, as well as by many others, in the design of clamping devices, jacks and other equipment and in the





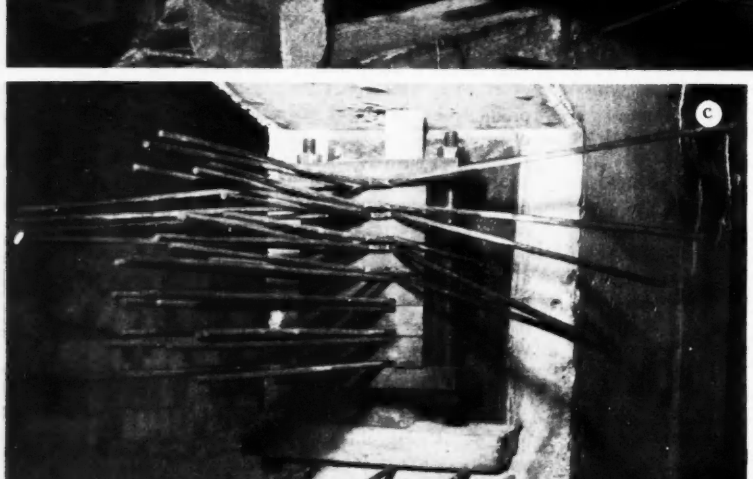


FIG. 5*a*.—Post-tensioned, pre-stressed beam showing high tensile steel wires threaded through a longitudinal duct cast in the beam, prior to the wires being stretched.

FIG. 5*b*.—The wires of the beam illustrated in Fig. 5*a*, being "tensioned" by means of a Magnel Blaton pneumatic jack.

FIG. 5*c*.—The wires after tensioning are clamped in position. The wires are then trimmed off and the end of the beam concreted up.

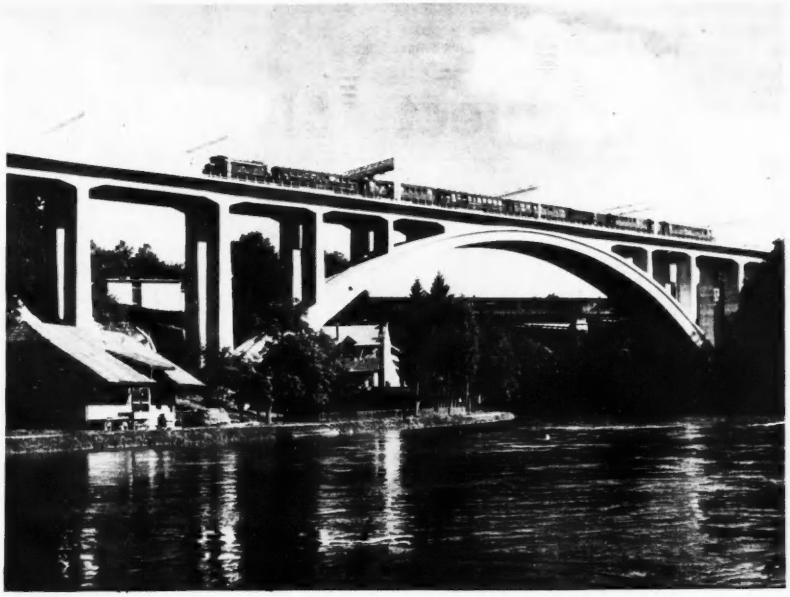


FIG. 6.—The Aare Bridge, built at Berne, in 1939-40 for the Swiss Federal Railways. With a span of 500 feet, it is one of the largest single-span reinforced concrete bridges in the world.

solution of the very many practical and theoretical problems which constantly present themselves. Indeed the possibilities of pre-stressed concrete are so enormous that it is the happy hunting ground for ingenious minds.

Its possibilities may be judged by the fact that, in suitable circumstances, it matches ordinary reinforced concrete for strength but uses up to 70% less steel than ordinary reinforced concrete, and 30–40% less concrete. It is particularly suited to bridge construction. By far the greater part of the load that has to be sustained by a bridge is the 'dead weight', i.e. the weight of the bridge itself. By using pre-stressed concrete the dead weight can be drastically reduced. This gives rise to simple structures, slender in outline and comparatively easy of erection, which are abundantly satisfying to engineer and architect alike.

But the advantages of this exciting new material do not end here. Pre-stressing has opened up vast new possibilities in prefrabication. For various technical reasons, structural members of pre-stressed concrete can be handled with much less danger of damage than can normal reinforced concrete, and they can be assembled much more easily and effectively. In addition they are lighter. These properties enable us to visualise new vistas in the field of prefabricated structures of all kinds. Concrete structural units can now be made by carefully controlled processes—carried out in factories and transported ready-made to the site; in this respect they may be compared with steel girders. In France, Freyssinet is building five prefabricated concrete bridges over the Marne. These bridges are composed of flat arches. The arches are made up of sections prefabricated in a factory some distance away, under ideal conditions—one might almost say laboratory conditions. They are then transported to the site, hoisted into position, and post-tensioned together. The bridge is built out as two cantilevers from the sides of the river without temporary supports.

Of course, bridge building can never be made easy. Great care and attention to details both in design and construction are just as necessary with pre-stressed concrete as with any other material, but the enormous difficulties which are presented by inclement weather and frost (which brings to a halt nearly all open-air concrete work) are now practically eliminated entirely.

And what of the future? Today pre-stressed concrete is only in its infancy. In Britain there are about 100 structures in which pre-stressed concrete is used either for the entire structure or for some part. The largest pre-stressed concrete bridge in this country has a span of 80 ft.: abroad the longest span to date is 200 ft. But one can predict with certainty that it will not be long before many of our largest buildings, bridges, tunnels and similar structures will be made of pre-stressed concrete.

There is one other aspect of pre-stressed concrete that fires the imagination. This material demands very strong concrete, and so a new impetus has been given to research into the means of improving the strength of concrete, and also into the problem of getting a concrete which hardens more rapidly. One such means is by vibration. Either the moulds containing the concrete in its wet form are vibrated or 'pokers', which is the name given to steel rods mechanically vibrated, are placed in the concrete to harden it and improve its qualities.

M. Freyssinet in a prophetic moment has said that it may one day be possible to reduce a rock to dust purely by applying vibration of the correct frequency, and by the same means reconstitute it. What immense possibilities this conception opens up! What engineering marvels such a development would produce! But that is another subject. One revolution at a time is quite enough.

Before his departure to New Zealand, where he is geology professor in the University of Otago, Prof. Odell took part in an expedition sent out by the Arctic Institute of N. America. It was on this expedition that Prof. Odell found the ice-worms which have attracted so much attention in both the scientific and the popular press. This article provides details on other aspects of the expedition.

Project 'Snow Cornice'

PROF. W. E. ODELL

THE Arctic Institute of North America, as everyone knows, is an institution of international character, with centres at Montreal and New York. Its declared policy is to plan and execute projects of research of all kinds in the Arctic and Sub-Arctic regions. Project 'Snow Cornice' was one such undertaking on the part of the New York branch, the first instalment of which was carried out during the summer of 1948. The second instalment, during the summer of 1949, was able to continue the same researches in geology, glaciology, meteorology, botany, etc.

A by-product of the expedition in 1949 was the first ascent, by four of us, of Mt. Vancouver, which alluringly raised its lofty head, of 15,800 feet, right above our advanced base camp, until then the highest unclimbed summit in North America. We found ourselves in early July, with this difficult ascent accomplished, and around us at our base the menacing snow cornices on the high ridges fast diminishing, yet the avalanches from the heights increasing in number, whilst the surface of the snow fields was becoming ever firmer by consolidation, though more uneven in nett result through melting: the latter constituted, incidentally, something of a hazard for our aircraft, our only link with the outside world.

What a spectacular region in which we were now to carry on our scientific researches! Up there at our advance base at 6000 feet above sea-level, on a rock-island, or 'nunatak' (to use the Eskimo term), we looked out on a vast sea of snow and ice, almost unbroken for 750 sq. miles.

Surrounding this great Seward Icefield are some of the highest and most massive mountains in North America. Mount Logan, 19,850 ft., and the highest summit in Canada, reared its tremendous southern precipices 14,000 ft. above the level of the icefield; and other dominating peaks, such as St. Elias itself, after which the whole range is named; Mt. Cook, and Mt. Augusta, apart from Mt. Vancouver and others, forming the gigantic rim of this inter-montane basin, some 38 miles long by 20 miles across.

It was through this rugged country that the survey party of the International Boundary Commission demarcated the frontier between Canada and Alaska nearly fifty years ago, when at great distances they sighted many of these peaks, measured them by the process of triangulation, and ran an irregular line from peak to peak—a most irrational if not crazy line, to which Canada should never have agreed, but that is an old question and contention. All the coastal area is in Alaska, but eastward and northward is a vast region of mountains and glaciers situated in the Yukon. From our coastal base at Yakutat, merely a Thlinkit Indian village in the old days, but now a modern air station, it was necessary to fly east 55 miles over the great piedmont Malaspina Glacier, which terminates in tide-water, and then we had to climb through a gap in the mountains to reach the Seward Icefield. It is a remarkable fact that through that gap has to pour all the pent-up accumulation of snow and ice of the icefield itself: it is the only outlet, 3½ miles wide, and we were not surprised to find that the tumultuous stream of ice was moving at the exceptional speed of 16 ft. per day in the middle, as measured by the photogrammetric survey under Walter Wood, our leader. This glacier was certainly heavily crevassed, and the great blue gashes or trenches, big enough in many cases to swallow a ship the size of the 'Queen Mary', extended for some 15 miles upstream to its source in the main icefield. Almost all the icefield is situated in Yukon Territory.

Our handy Norseman plane, piloted with great skill by Maurice King, had been fitted with a new design of landing gear comprising skis and retractable wheels. So that having taken off the runway at Yakutat normally on wheels, we alighted on skis on the snowy surface of the Seward basin. This, however, required considerable skill at times, particularly under conditions of ground fog, and when, what we called 'firn-pipes' of ice projected like ice-hummocks above the general surface. And taking off again was rarely easy, since the surface became sticky during the day, and it was sometimes necessary to wait for hours, and until the surface refroze, before enough speed could be attained to lift the plane.

Near what we called the 'airstrip', used by the plane, a cache of spare equipment and stores had been made in 1948, before the evacuation of the party. On arrival in 1949 in early June, we had the arduous task of digging down through 14½ ft. of hard snow and ice to recover these stores. This figure of 14–15 ft. gives a measure of the snowfall up there during the winter. Here too was sited the main station for glaciological studies. Prof. Robert Sharp, of the California Institute of Technology, with a team of five graduate students, was in charge of these special researches, the first of their kind to be carried out in North America. They comprised a measurement of the progressive melting, or ablation, of the surface snow, or *névé*, of the main icefield; a study of the texture and structure of this *névé*, and additionally a sounding of the depth of the immense icefield by seismic methods, as well as by a new technique of radar survey. These studies were carried on from June to September, and it is hoped that the results may prove to be a worthy counterpart of the similar intensive researches that in recent years have been in progress in Scandinavia, Greenland, and Switzerland particularly.

My own special responsibility was the solid geology—a survey of the rock formations of the region and their structure. Having studied the structure of so many other mountain ranges, in Great Britain, Norway, the Alps, the Himalaya, apart from the Rockies, I was anxious to learn

FIG. 1.—Base camp on the Seward Glacier, at about 5800 ft. Mt. Vancouver, which rises to 15,800 ft., is seen in the right background. The Norseman plane flew over the peak in left-centre background.

FIG. 2.—Glacier pool on the Seward Glacier, 6000 ft. up: here the author found living ice-worms. The Mt. St. Elias Range can be seen, with Mt. Vancouver 30 miles behind it.

FIG. 3.—The top of Mt. Vancouver, from 13,000 ft. In foreground is seen what is probably a moraine.

how these great ranges of Alaska and Yukon had come into being. In the course of one season, however, only a general idea could be gained. The scale of the country, the immense distances to be travelled between rock outcrops in many cases, difficulties of terrain, apart from the ever-present hazards of the weather, would all tell against the accomplishment of so complete and detailed a survey as one would otherwise expect. I had hoped, moreover, to have the use from time to time of our Norseman plane, in order to reach the more distant outcrops and mountain faces for geological examination. This latter facility had, however, to be severely curtailed, either for reasons of bad flying-weather, or owing to vital transportation requirements elsewhere.

Instead, I had the not altogether unwelcome task of travelling mostly on skis over the glaciers and snowfields in order to reach my objectives. Up there in the St. Elias

Range, one met all kinds of obstacles and difficulties. Sometimes there was very bad snow, more of the consistency of mud; at times there were crevasses to dodge one's way through, and often there was thick fog or cloud right down to the surface of the snow, so that one could judge little of the irregularities of it or even tell sometimes whether one was going uphill or downhill. Then one would have to park one's skis, after perhaps many miles of travel, and climb some rock or iceface, which called for experience in mountain craft. Not infrequently while I was working on some mountain face I would be visited by a bird or two. Some of the birds may be summer residents on the lower rock outcrops, but mostly they must be migrants. Why even humming birds should choose to fly across the high St. Elias Range is, however, not so easy to account for! There were lowly alpine plants in evidence in the more sheltered places, and it was a delight to see beautiful blooms of hare-bells or bluebells, Epilobium or fireweed, and various flowering mosses as well as arctic willow, appearing by late July or early August.

As to the structure of the St. Elias Range in general, all I can say here is that it is largely made up of metamorphic rocks, the result of great compression throughout the region, and of intrusion of certain igneous rocks, such as diorites, which by their resistance to erosion now stand up as the principal peaks of the range, for example, Mts. Logan, Vancouver, St. Elias, Cook, etc. I could find no minerals of economic importance in the region.

There seems to be ample evidence that this great basin of the Seward Icefield was once filled with a far greater depth of ice and snow. On our ascent of Mt. Vancouver, I found evidence of a probable moraine at some 13,000 ft. But, in any event, the ice flood seems to have been sufficient to spill over through gaps at an elevation of at least 11,000 ft. in the surrounding ranges. When that was the case, during the Pleistocene ice-age, a good many of the mountains must have been well-nigh submerged and great outward-flowing glaciers must have built up immense ice-fronts along the coast, of which the present Malaspina glacier near Yakutat is but a small relic.

In such a region as this, hampered by bad weather that kept us at times in our tents, or, in our excellent Jamesway hut at the Base Nunatek, where we usually found ourselves oversleeping or overeating, we were always anticipating settled weather of sufficient duration to see something of the surrounding territory, to view closer the little known region to the north. In mid-August an opportunity arrived, a day or two of cloudless skies, and I was a participant in one of the most spectacular flights that has ever fallen to my lot.

From the airstrip on the Seward Icefield we flew north and west over the rim of the basin, and out into the wide open spaces to the north of Mt. Logan. Beneath were immense glaciers, and to our southward the great wall of Logan itself, sweeping up to its 10-mile long summit crest, that one of our passengers, Henry Hall of Boston, had known intimately during the Canadian-American ascent of 1925. Hall had paid us a visit with the express purpose of seeing something again of this, one of the greatest mountain masses of North America. Then, we veered north again, and threaded our way between giant summits deeper in Yukon Territory, especially Mt. Lucania (17,150 ft.) and Mt. Steele (16,439 ft.) and Mt. Walsh (14,780 ft.). I was intent on studying what one could see of the general structure, the tilted and faulted beds of which these mountains are formed; and also observing the amazingly contorted lines of moraine on many of the glaciers, which are such a feature of this region. Walter Wood, who had conducted several earlier expeditions on foot into this country, was absorbed in looking down on Mt. Steele and Mt. Wood and others of which he had made pioneer ascents. We came in sight of beautiful Kluane Lake and the Alaska Highway, which later my wife and I were to traverse en route from Fairbanks to Whitehorse; and then we turned south past Mt. Alverstone and Mt. Hubbard, situated due east of Mt. Vancouver, all being points on the International Boundary. As we veered towards the north-eastern precipices of Vancouver, our engine began to splutter ominously, but soon picked up on the switch-over to another fuel-tank. It was astounding now to view our route up Mt. Vancouver, poised in space at 13,500 ft. We could only congratulate ourselves that we had been able to accomplish so long and arduous a climb when we did six weeks ago. A dive over the ridge, and along the southern cliffs of the mountain, soon brought us in a series of steep spirals to the airstrip camp on the Seward Icefield. In two hours' flying time we had covered about 200 miles over some of the ruggedest and most inaccessible mountain country in all North America.

One last point. Recently I have noticed in Canadian and American newspapers desultory and inconsequential talk on the subject of 'ice-worms'. Everyone seems to want to emphasise that ice-worms, or glacier-worms, actually exist, in spite of their being a myth, if not a hoax, to others. Well, I can claim that I found some on the Seward Icefield at 6000 ft. this summer; and a good specimen of about one inch in length I brought back, preserved in alcohol, to the Department of Zoology, in the University of British Columbia. To Alaskans ice-worms have been a joke for many years, and at Juneau one can buy postcards depicting so-called 'Spaghetti on ice'. Nevertheless, they are a definite and peculiar worm which chooses to live on the glaciers, feeding, it is thought, on the algae which form 'red snow', and dying when taken out of the snow. They are found extensively at times in the Coast Range of B.C., as Mr. Don Munday has remarked in his recent book *The Unknown Mountain*. There is a lot yet to be learnt about the life history and habits of these worms, which are definitely a species of oligochæte; but no longer is there the basis for the colossal joke which they seem to present to the people of Alaska and to many visitors to that spectacular and romantic country. A letter, which I wrote to *Nature* (164. 24.12.49) on the subject, was responsible for a reply, not unmingled with mirth, from the secretary of the International Snow Worm Club of the Olympic Mountains, Washington, who categorically stated that membership of the club, and a certificate, were available only to those who capture their own ice-worms.

Another facetious suggestion by a correspondent to the *Daily Telegraph* (2.1.50) that ice-worms may form the main diet of the 'Abominable Snowman' of the Himalaya remains invalid until the existence of such worms, quite apart from the Snowman himself, is definitely established in that region. So far these worms have only been recorded from the coastal ranges of North America, and parts of the Canadian Arctic.

Artificial Rain in South Africa

KEITH PULVERMACHER

ABUNDANCE of water would change the whole economy of many dry countries in the world, for there are vast areas which would be fertile were it not for a lack of the key to all farming and industry—water.

Scientists are looking ahead to try to provide it. Their ideas run along several lines, one of which is to make rain artificially. Some scientists visualise this technique being completed with the provision of larger networks of dams to store the water which the clouds are induced to yield.

In this field the U.S.A. has so far led the research all the way, and some promising results have been achieved, although it will be many years before any really conclusive data can be provided. The reason is that it seems impossible to prove that a cloud would not have rained anyway. The only proof of artificial rainfall looks like being in the pudding, as it were—in statistics of rainfall over a long period, indicating yearly averages at noticeably higher figures than over a previous long period.

In South Africa, which would be a very rich country indeed if it had high rainfall, there has been considerable interest in artificial rain-making.

Research since 1948

Despite the endeavours to stop water from being brought down from the clouds (on grounds of 'sacrilege!') by persons who do not mind pumping it up from the ground, research has been carried on on lines similar to that practised by the Americans. The South African Council for Scientific and Industrial Research in Pretoria (South African equivalent of Britain's DSIR), in co-operation with the Weather Bureau and the South African Air Force, has been carrying on research since 1948. In that year there were successful, if inconclusive, experiments in which dry ice was dropped into suitable clouds.

In 1949 further experiments were carried out with other substances. These included water, calcium chloride solution, and silver iodide smoke. Conditions were not as favourable for these experiments as had been hoped, and the results were again inconclusive.

Nevertheless, the indications were that the silver iodide smoke was quite as effective, if not more so, than the other substances. It had the advantage that it could be released from *below* the clouds, instead of having to be dropped from above. The smoke released from below a cloud would be drawn up by convection currents and carried up to the freezing levels at which it would be effective in causing super-cooled water vapour to turn into ice particles, and so start the chain reaction which leads to the formation and deposition of raindrops.

A further series of experiments was carried out from Waterloof Air Station at the beginning of 1950. Unfortunately, a special aircraft could not be set aside for these experiments, so the researchers had to be content with releasing the smoke from the Harvard trainer which every afternoon climbs to 17,000 ft. to take temperature and humidity observations for the Weather Bureau. This meant that the silver iodide smoke had to be released in the vicinity of Waterloof as the aircraft could not go in special search of suitable clouds.

The silver iodide smoke was produced by a generator developed by the National Physical Laboratory of the CSIR. Before starting the experiments, some work has been done in the laboratory. First, the average size of the silver iodide smoke particles was determined with the aid of an electron microscope; this was found to be about six-millionths of a centimetre. This was shown in a cold chamber to be effective in causing air supersaturated with water vapour to turn to ice crystals—which is believed to be the first stage in starting natural rainfall. The cold chamber tests also indicated that the rate at which the silver iodide left the generator was also satisfactory. When the smoke was introduced into the chamber the water vapour turned to ice with tremendous speed, indicating how rapid the chain reaction can be.

Thus it could be reasoned that, if the silver iodide could be introduced into suitable clouds, it should induce precipitation.

As there were not always suitable clouds in the area in which the silver iodide was released, the results could only be determined by calculating the probable drift with the upper winds and by detailed analysis of the rainfall records. Once again the results were not conclusive, but justified further experiments.

The Silver Iodide Technique

When news was received of American experiments from the ground, the CSIR decided to try this too. It had an obvious advantage in eliminating the expense of an aircraft. The National Physical Laboratory developed a very simple generator, consisting essentially of an ordinary spray gun. Pressure for the gun was provided by a hydrogen cylinder. The silver iodide was dissolved in acetone and a fine spray produced. This was lighted and silver iodide smoke wafted away. Once again the size of the particles and the rate of flow were studied and adjusted to the proper ranges by varying the strength of the solution and the pressure of the hydrogen.

The main problem in generating silver iodide from the ground is to determine the area over which it drifts. This is most difficult to achieve accurately and the best that can ordinarily be done is to choose a position for release where hot air is known to rise, or where air rises for other reasons —such as up the windward side of a hill.

It was noticed that in the mountainous region of the Cape Midlands, between Middelburg and Graaf Reinet, clouds roll up most afternoons during the summer and very seldom release any rain. This seemed to be an ideal testing ground. As one of the CSIR staff was going to spend his leave in this area, he was given the equipment to test when conditions were suitable.

Unfortunately, the weather during his leave was not normal, except for four occasions. On all four, rain storms

Silver iodide crystals are similar in shape to ice crystals and so provide nuclei on which the supercooled water vapour in a cloud can condense. It has proved the most promising material to bring about the deposition of artificial rain. This picture shows a generator producing silver iodide smoke for one of the S. African experiments. (*Johannesburg Star* photograph.)

developed about 5 miles from the position of release. On one occasion 0·7 in. of rain fell in half an hour in a limited area—the only storm within 15 miles and with sharply defined boundaries. On another occasion a similar fall occurred, again with sharply defined boundaries. Lighter falls were recorded that night in the neighbourhood, but this was the only heavy one. A farm at the centre of this storm gauged 1·05 in. On both of the other occasions sharp showers fell—at least two hours before any other appreciable rainfall occurred within 15 miles. One of these gauged 0 25 in. and the other 0 15 in.

CSIR scientists do not consider that these results can in any way be regarded as conclusive evidence that the silver iodide smoke affected the rainfall.

Nevertheless, they are not prepared to disregard entirely the following points:

1. The storms occurred on the four occasions when the silver iodide could reasonably have been expected to be effective.
2. On all four occasions the silver iodide was released in a northerly wind and on each occasion the rain fell about five miles south of the release point.
3. On none of these occasions did the rainfall extend to the west of the release point, which, in this particular position, showed clearly that the rain started in the area and did not drift over from the north, west or south.
4. On all four occasions the rain occurred suddenly.
5. On all four occasions observers were surprised that rain occurred at all, as the weather conditions did not look 'likely'.

As a result CSIR scientists are now considering more detailed experiments.

In the U.S.A., where rain-making experiments have been carried out on a considerable scale, scientists appear to have had some outstanding successes—although they are the first to say that these are not conclusive. Particularly, they seem to have succeeded not only in inducing rain where none would have fallen, but also in extending the area and time of storms.

Some day, even if artificial rain-making has not been proved scientifically, rain may follow cloud-seeding so consistently that it will be adopted. Then a big engineering problem will arise—that of providing at low cost dams to prevent the rain from merely running into the sea.

What are Allergies?

HELEN CLAIRE HOWES

Does it ever occur to you as you wipe your streaming eyes that you may be suffering from a 'disease of adaptation'? Well, you may be.

Some diseases of adaptation appear to be those benefited by treatment with ACTH and cortisone. Scientists have shown that both these substances can relieve the symptoms of certain allergies as well as rheumatoid arthritis.

Arthritis and related conditions used to be considered 'of unknown origin'. No one knew what caused them, nor why some people developed them while others did not. They are now believed to stem from the individual's inability to adapt himself to the stresses in his physical, mental, and emotional environment. Dr. Hans Selye, the Canadian scientist, says that the body inflicts these maladies upon itself as by-products of its own efforts to fight off some other challenge to its well-being.

Now, some scientists think that allergies also have their origin in the body's attempts to adapt itself, and that the necessity for adaptation can be traced back to when animal life first encountered sharp changes in weather, new foods, irritating weeds, chemicals, bacteria, frustrating emotions, and so on.

The human being has, on the whole, been highly successful in adapting himself, in so far as the race has been perpetuated. Most of us, in fact, have adapted ourselves to practically everything we come across in every-day living. Hans Selye once wrote "there is perhaps a certain parallelism between the degree of aliveness and the extent of adaptability in every animal and in every man."

There may be substances to which no one is adapted, but if we do not encounter such substances, we do not consider ourselves allergic to them.

It may be that when an allergy develops, the adaptive mechanism has not functioned properly: instead of the person becoming accustomed to house-dust, for instance, and immune to it, he shows an allergic reaction. Or again, if the individual is under continuous and severe pressure or stress from something in his environment, the protective mechanism may work so hard that it exhausts the body's resources; he then develops a severe disease of adaptation that may lead to complete exhaustion and death.

The immediate causes of allergy are still very controversial, possibly because there are so many different kinds of allergy. Workers at the Mayo Clinic have grouped all known types into three main classes.

Kinds of Allergy

A man or animal is said to be allergic if he is susceptible to a substance in an amount that proves harmless to the majority of the species. A different type of allergy is shown by those individuals who are allergic to extreme cold.

There is one class of allergy called *anaphylaxis* which can easily be produced in laboratory animals, and the bulk of experimental work on allergies has been done by bringing on this reaction and observing the results. Two doses of a substance (usually a protein) known to produce this effect are injected sufficiently far apart in time to permit the test animal to become sensitive to it. Such a substance (that makes an individual sensitive) is called an 'antigen'. The second dose of the antigen causes the shock reaction—the *anaphylactic reaction* as it is called—which may end in death. Oddly enough, if only a moderate (prophylactic) dose is given, the animal is rendered immune.

The term *physical allergy* covers a large group of abnormal reactions to cold, heat, light, changes in atmospheric pressure and temperature, and fatigue. Emotional disturbances such as fear, resentment, jealousy, rage, and anxiety can cause allergic responses too: acute headaches that come on after a fit of tantrums provide an example of this. Such disturbances can produce eczema, asthma, hives, running nose, etc., in some susceptible persons.

Another type of reaction (it is really a mild form of anaphylaxis) is caused by eating protein or carbohydrate (e.g. egg, and starch). This kind of allergy results in swelling of some tissues, skin inflammation and hives. This kind of allergy tends to run in families. However, an allergy can be acquired—to liver, for instance, by pernicious anaemia patients injected with liver extract over a long period. Certain drugs and chemicals (e.g. salicylic acid) can cause allergic reactions, even at the first encounter.

There is *contact allergy*, a reaction produced in the skin when it comes into contact with such things as poison ivy, pollen, certain dyes, and chemicals. The case is recorded of a man who was allergic to the metal rims of his new spectacles; his swollen neck and running ears cleared magically when he changed to plastic rims—although the latter can cause similar symptoms in a person allergic to plastics!

Age makes a difference in the occurrence of certain allergies. In this connexion babies are more sensitive to certain foods. In the adult, substances that are inhaled—such as house-dust, pollen, and cats' hairs—cause reactions more frequently than foods.

The three main groups of allergy into which all these different kinds of allergy fall are: (1) Physical Allergy; (2) Bacterial or Tissue Allergy; and (3) Humoral Allergy. Patients may show more than one kind of allergy at the same time.

Theories about Causes of Allergy

In the last hundred years or so many explanations have been offered as to cause. A school of German physicians once advanced a theory that in all types af allergy there are 'antibodies' circulating in the blood and body fluids of every allergic person. Their slogan was "no antibodies—no allergy".

Now an antibody is something that, in immunity and *in some types of allergy*, is produced by the body itself as a defence against a second encounter with a substance (usually a protein) that is foreign to the body. The first contact with the substance (called the *antigen*) stimulates a *normal* individual to form antibodies designed to protect him in the future. The person is then said to be immunised, i.e. safe against attack; the body of a child vaccinated against small-pox produces antibodies that will protect him against small-pox germs.

Some specialists believe that there is no fundamental difference between the antibodies produced in immunity and those found in some types af allergy. They think allergy is only a case of hyper-immunity, the device that protects against disease having gone a little too far, having overdone a good thing.

The theory that antibodies are present in the bloodstream of *all* allergic individuals still persists in some circles today. Yet in the majority of persons telling their allergic trouble in the doctor's office, no antibodies whatsoever can be found. (The diehards insist that the antibodies are there all right; we just aren't smart enough yet to detect them!)

For instance, *physical allergy* does not cause any antibodies to form. The man who gets hives every time he indulges in a spree of resentment does not develop antibodies in his bloodstream to protect him against resentment. Persons allergic to intense cold, poison ivy, chemicals, etc., show typical symptoms although no antibodies are found in these patients either.

Then, if it is not antibodies that make you sneeze at golden-rod pollen, or give you hives, or a headache, or make the test animals die from anaphylactic shock, what is it? Allergists say that the actual symptoms are caused by the release of *histamine*, a substance normally present in the body. It has the power to enlarge the minute blood vessels, the capillaries, to such an extent that their walls become permeable. Body fluids (called humors by some) can then leak through, gather in the skin, and produce hives that itch like fury.

The question naturally arises: "If histamine is normally contained in the body, why does it suddenly run berserk and act like a poison?" Histamine is released only when the tissue cells are injured; normally it lies quietly in the tissues in what is called 'bound form'. The injuries that break down the cells come about in different ways *in the three main groups of allergy*.

In the *physical allergies*, the stimulus of cold, change in temperature, etc., may release histamine into the bloodstream and so lead to the usual allergic reactions. This is brought about by a chain reaction triggered by the autonomic nervous system—that network of nerves which serves the heart, glands, smooth muscles, etc., and which keeps them running without our ever thinking about them.

According to the latest theory of allergic reactions, worked out at the Mayo Clinic, *physical allergies* probably had their rudimentary form in the 'alarm reaction' described some years ago by Hans Selye. (This is getting considerable publicity just now because of Dr. Sleye's book *Stress*, and the world-wide interest in cortisone and ACTH.)

When life consisted of a single cell, or a few cells formed together, only slight changes were required to relax it and set things right after it had received a rude shock from the world outside itself. As the organism became more complicated, such disturbances necessitated certain changes being made to permit quick readjustment. These changes eventually resulted in the development of an endocrine system. The endocrine glands such as the thyroid, and pituitary, secrete hormones that react on the other cells and tissues of the body, speeding up their reactions. Later (in the evolution of animals), other groups of cells became more specialised, and the autonomic nervous system was developed. Now the glands, their secretions, and the nerves all act and interact with one another.

For instance, the unexpected appearance of a bear alerts our defence mechanisms, both nervous and endocrine. A message is sent by the brain to the adrenal glands, which pour their hormone into the bloodstream and through the body. The heart jumps wildly and pumps the blood more quickly. When the adrenal hormone reaches the respiratory centre of the brain, the person gasps, giving out carbon dioxide more rapidly than it can be made in the body, and taking in more oxygen than is required. The balance between these two is upset. The adrenalin influences the anterior lobe of the pituitary to pour out ACTH; this reacts on the adrenal glands, and so on. The muscles, in the meantime, are stimulated to act; we turn and run faster than we believed possible. Even if we merely thought a bear would meet us in the path, we would probably respond with the same reaction. The same chain could be set into operation if a thief saw an unobtrusive policeman immediately after he had robbed a bank.

It is clear, therefore, that the alarm reaction can be set off by a stimulus in either the external or internal environment of a person—fear of a real thing, fear of a possibility, or a feeling of guilt.

The allergic individual may have inherited a tendency to react in a peculiar way to certain physical stimuli that, in another person, produce no such reaction. A spasm may occur in the smallest blood vessels, which prevents the blood from flowing through normally. That area is starved for blood and, therefore, for oxygen since the red cells carry the oxygen around the body. Cells that lack oxygen are injured; their histamine is released into the body; the walls of the tiny blood vessels become porous; fluid seeps through; hives form, and other typical symptoms develop in the person with *physical allergy*, whether it is caused by a chemical, poison ivy, severe cold, or emotions. This is the typical reaction of the person who develops hives following the hot flush of resentment. *No antibodies are produced in the body in this type of allergy.*

In the group referred to as *bacterial* or *tissue allergy*, in which antibodies *are* produced, antagonism between antibodies and another dose of the antigen causes the release of histamine.

After the human body learned to adjust to most physical irritations, the next step was the preparation to defend itself against germs. Antibodies against invading bacteria developed in the tissue cells in an effort to make the individual immune to further invasions. (Antibodies are normally present in persons immunised against a disease.) In the allergic person, however, instead of protecting the person, the antibodies apparently wage war with the invading bacteria *within the cells themselves*. The battle proves so violent that the city itself is badly damaged! In the skirmish, cells are injured so that histamine is released. The same changes occur in the small blood vessels as is produced in *physical allergy*, with the same result—swollen tissues, running eyes and nose, asthma, eczema, etc.

In the third group, called *humoral allergy*, conflict between antibodies and antigen again causes trouble. In this type (a large development for mankind) the antibodies at long last *do circulate* in the blood stream, as the German scientists thought, but they do so *only* in this type of allergy. The same civil war takes place between antibodies and a further invasion of the antigen as takes place in

tissue or bacterial allergy. The results are identical—injured cells, released histamine, allergic reaction with its various symptoms.

Treating the Allergies

The best way of treating an allergy is to find its cause and remove it. In many cases, the cause (the antigen) cannot be found. Then it becomes necessary to look into the emotional life of the patient.

If the cause happens to be a substance met with in everyday living, it may not be possible to avoid it—like the man who was declared allergic to *everything* except Arctic moss, yak hair, and pomegranates! It may be possible to desensitise the person by giving him gradually increased doses of the substance that causes the trouble. Where emotional disturbances play a part (and this is much commoner than has been supposed), psychotherapy may be applicable.

Persons who are sensitive to certain kinds of weather—humidity or cold, for instance—naturally improve in a dry, warm climate. But where the home situation is unsatisfactory, they improve only if they leave the family behind.

The medicines most commonly used today in treating allergies are the antihistamine drugs, so-called because of their inhibiting or counteracting effect on the histamine or histamine-like substances released in the body. Eighty-five per cent of allergic persons are said to be relieved by these drugs. Dogs, cats, horses, and other animals are also receiving the benefit of antihistamines for their allergies.

To summarise: The human body gradually developed a way of protecting itself against irritating weather changes, frustrating emotions, bacteria, and noxious substances, and added new developments to the primitive means of defence as they were needed. Allergy is one kind of failure of this protective mechanism to function properly.

This theory, with its reasonable grouping of all allergic reactions into three main groups, answers many questions that have puzzled doctors and patients alike. The form all allergies take depends upon the individual's inherited make-up, the type of stress he is subjected to, the substances in his environment and his diet, and, where animals are involved, the species.

When the antihistamine drugs were first discovered, they probably provided the greatest clinical advance in the treatment of allergies made in years. However, discovery of the values of the new hormone preparations represents a far greater advance than the antihistamines because they can be used on a much wider range of diseases, including the allergies, and they open up vast new fields for medical research. Unfortunately, cortisone and ACTH are far too scarce and costly to be used for any but the most extreme cases at the present time.

If further experience proves beyond doubt that the allergies do belong among the diseases of adaptation, scientific study of these exasperating afflictions will proceed along the same channels as research into the cause and cure of such diseases as arthritis, hypertension, etc.—the more serious, and often fatal results of the body's failure to adapt to its environment without penalty.

Tribute to "Discovery"

On two occasions recently, L. J. F. Brimble, joint editor of *Nature*, has referred to the valuable work done by *Discovery*. The first was a lecture at the Imperial College of Science and Technology, when he criticised severely the handling of science news by the British newspaper Press. Again, during a lecture on "The Literature of Science and Technology" to members of the Booksellers' Association at the Regent Street Polytechnic, he compared and contrasted British publications under the three general headings Science for the Scientist, Science for the Student and Science for the Non-Scientist.

Referring to *Discovery* Mr. Brimble said that no other country in the world publishes such an effective journal, adding that even the general and comparatively easily read science journals of the United States do not achieve such a high standard. "Perhaps the best one published in the U.S.A. is far too biased in favour of the physical sciences," commented Mr. Brimble. He saw that *Discovery*, on the other hand, not only publishes many good things, but it also very carefully covers *all* important branches of science.

"The true import and message of science is grossly misunderstood by the majority of non-scientists. Even otherwise well-educated and intelligent people look upon science as something mystic, magical or mischievous. All too many people, when thinking of science, think in terms of atom bombs and deadly bacteria; and if at any time they condescend to acknowledging something good, it is seldom in anything but the medical sciences. *Discovery* is doing a real job of work in counteracting this lack of balance. Whereas *Nature* is written by scientists for scientists and, therefore, these days is almost unreadable, *Discovery* brings the message of science not only to scientists reading outside their own specialism but also to many non-scientific readers," he said.

Mr. Brimble expressed the opinion that such a journal should be placed in the general reading rooms of all educational centres (school and university), and in all public reading rooms. He considered the importance of *Discovery* lies not so much in the knowledge it imparts as in the policy it pursues.

Limestone or magnesian limestone is used for making mineral wool.

Mineral Wool Manufacture

J. A. RADLEY, M.Sc., F.R.I.C.

ABOUT 120 years ago, an American scientific expedition to the Hawaiian Islands discovered a wool-like substance on the slopes of Mt. Kilanea. It proved to be mineral in nature and had been formed during eruptions of the volcano when masses of lava had literally been 'blown to shreds' by the huge volumes of superheated steam and hot gases released in the eruptions. The natives called it "Pelée's Hair", Pelée being the native god of volcanoes. The scientists noted that the natives used it to 'blanket' their huts, and that these remained cool in hot weather, yet warm in cooler weather.

The scientists took back samples of this material to the United States. Given the idea that mineral wool was a good thermal insulator and that it might be produced artificially by simulating something of the same kind of conditions that lead to its formation in volcanic action, it was not long before the enterprising Parrott family, which had made guns in the Civil War, started to make 'slag wool'. Raw material for the process was abundantly available in the large iron slag heaps which had accumulated at their factory. Thus, whilst General Grant was still President, commercial production of mineral wool for thermal insulation began; and now today the manufacture of slag wool, mineral wool, and glass wool is carried on in many parts of the world. It is a highly effective material for sound insulation as well as heat insulation.

The original slag wool was far from perfect. This is not surprising, as the slag, a by-product from the manufacture of pig-iron, consists of the various impurities contained in the iron ore, fluxed in a blast furnace with limestone to produce a very impure 'glass' of varying composition. As the constituents of the iron ore can vary widely, the slags produced differ widely in composition, and have varying amounts of free lime which is affected by water or weathering.

The idea has developed of manufacturing a product in which the composition would be held within strict limits, thus producing a consistent and stable product as the intermediate material from which the final mineral wool would be made. Such a process has been developed by a British firm, which has erected a factory on a site in limestone quarries at Matlock. The minerals used for making the mineral wool are magnesian and Carboniferous limestones, and clay of high alumina content, while the requisite flux is obtained from an adjacent deposit of fluorspar. In 1947 a rock wool pilot plant was designed and built, and today it has a weekly capacity of 50 tons. This material is marketed under the name of Cawdorite.

A melt of known composition is produced by using a carefully balanced mixture of clay, limestone, magnesian limestone and fluorspar. The plant consists of a cupola furnace some 16 feet high, lined with refractory bricks into which is charged first a portion of the batch, then a layer of coke, a second portion of the batch, and so on. Air is blown through inlets at the bottom of the furnance above the hearth. Towards the bottom of the furnace a temperature as high as 1600° C. is reached. The product is a sort of molten glass, which flows down into the base of the furnace. This is constantly tapped off

Loose mineral wool as produced in the factory.

from the hearth, and fresh coke and batch mixture are added at the top of the furnace so that the whole process is continuous.

As the melt runs away from the hearth through a tapping hole, in a thin, continuous stream, it is met just below the lip of the tapping channel by a blast of superheated steam, directed at right angles to the cascade. This blows it in a finely divided form through an inclined tunnel, in a direct line with the steam jet, into a collecting room. In the tunnel the little globules of melt are stretched into fibres by the force of the steam, a 'head' of molten material being followed by a growing 'tail' of fibre, very much like a comet. The 'head' continues to diminish in size and the fibre tail to grow until the temperature of the material has fallen to a point at which it is no longer molten. The soft wool-like substance showers down into the collecting room like large fluffy snowflakes, from which it is continuously removed by a slow-moving wire conveyor-belt upon which it settles, into a storage chamber where it is finally baled for dispatch. It is possible to vary the properties of the material by suitable alterations in temperature and in composition of the original batch. The finished product looks like a felted mass of off-white wool fibres, which is soft to the touch.

In another process for making mineral wool, the molten slag is fed on to a wheel revolving at great speed in a jet of steam. The melt is flung off the edge of the wheel by the centrifugal force, in the form of tiny droplets, and these meet the steam blast which then extends them into fibres. In the manufacture of rayon or 'artificial silk' a solution of viscose is forced through minute holes in a die and are coagulated in a bath of chemicals. The same type of process is applied to the manufacture of true glass wool, molten glass being forced through tiny spinnerets to form fine threads which solidify on cooling after being extruded. Such fibres can be woven into braid, or into cloth, which has many valuable uses.

Average fibres of mineral wool are 1 to 1½ in. long, and 0·0002 in. diameter; there is but little variation about these mean dimensions.

Since the material is virtually a glass, it is resistant to acid and alkaline attack, hydrofluoric acid excepted, and those materials to which glass is resistant. It can be heated to 800° C. without losing its wool-like character; it does not melt until it meets a temperature in the neighbourhood of 1,400° C. It is a good electric insulator and stable to weathering. For thermal insulation its efficiency is only exceeded by felt, hair, or wool, which are generally regarded as the most efficient thermal insulators available.

The low heat transmission makes it valuable for the heat insulation of buildings, and a 1-in. layer over the rafters in the ceilings greatly increases the warmth of the building.

The complete inertness of mineral wool to flame has proved of value on many occasions in checking the spread of fires, and a 1 or 2 in. thickness of the wool over a board will completely protect it for some time against a fierce heat raging on the outer side of the thermal insulation.

Mineral wool finds many uses in industry, for example in lagging cabins and hot and cold water tanks in aircraft and ships. Not only does it find use as a highly efficient thermal insulator, light in weight, fireproof and unaffected by changes in the moisture content of the atmosphere, but it is also proof against bacterial and fungoid deterioration, or attacks from rodents. In factories it is easy to erect prefabricated screens or 'batts' around a particularly noisy piece of machinery, and it has the remarkable property of deadening sound, reducing the noise from the machine, or work in operation, to about 5 or 10% of its normal volume, thus lessening the mental strain upon the workers and improving the amenities of the district surrounding the factory. Such rapidly erected insulation is useful, for example, around test benches for aeroplane and motor engines, whilst further more permanent structures, incorporating mineral wool for its sound-deadening properties, are telephone booths, typing rooms, hospitals, creches, offices, and blocks of flats.

Far and Near

Is the H-Bomb Now Practicable?

THE June 4 issue of *Time* carries the following story, which appears to have escaped altogether the attention of the British Press:

"In a cryptic, 20-word sentence, the Atomic Energy Commission and the Defense Department last week gave a progress report on the H-bomb. Said a joint press release: recent 'successful' atomic tests at Eniwetok 'included experiments contributing to thermonuclear weapons research'. AEC and the Defense Department would not elaborate, but the reference to 'thermonuclear weapons' provided grounds for some informed guesses. Scientists have long known that the only way in sight to start the fusion of hydrogen atoms is by extreme heat—and the only known way to generate such heat is by an atomic explosion. Thus, an atom bomb would have to act as the 'trigger' for any H-bomb. Last week's announcement did not mean that the U.S. already has an H-bomb. It more likely meant that an atom bomb has been found feasible as a trigger for the H-bomb, and that possibly some heavier hydrogen atoms had actually been fused in the experiments. If so, that was a big jump ahead in the grim, global atomic race."

There are some who go beyond the *Time* story, and take the view that the H-bomb can now be put on the production line. America's technical and industrial capacity is such that the H-bomb, once it is proved to be a practical proposition, could be manufactured.

* * *

On June 13 Lieutenant-General Quesada, commander of the task force which carried out the experiments at Eniwetok, held a Press conference, accompanied by Dr. Alvin Graves, his scientific deputy. According to *The Times* of June 14, he said that the experiments were designed to "test new and improved weapon designs." He also referred to experiments contributing to research on thermonuclear weapons.

General Quesada said that during the experiments the force of each detonation was measured in the first few millionths of a second to prove the efficiency of new atomic bomb designs. The growth and rise of atomic clouds were investigated, and associated radiation fields were plotted. Various types and designs of building construction were tested, and different kinds of aircraft were exposed to varying degrees of blast and heat. It would be some months before all the data collected had been sorted and arranged into a form useful for civil defence organisations. But, according to an officer who had made a particular study of residual radiation, there was no need to fear that it will be impossible to approach the wrecked buildings because of the danger of burns.

He stated that atomic mid-air explosions, in spite of their deadly heat and blast, do not leave the target area poisoned with radio-activity which would delay prompt rescue operations. "The mysterious ghost of lingering radiation should be dispelled," he declared.

He said that the tests proved that the new models were "several times more powerful" than those used against Japan at the end of the war.

The Science Technologists Association

FOR many years technicians in Britain's science laboratories in educational institutions and industry have been conscious of the need to raise their status and to provide schemes of training with a view to certification at a professional level. Many widely spread attempts have been made by technicians and employers to carry out this very desirable purpose. Lack of co-ordination and all too often unsuitable syllabuses of study have in most instances rendered these efforts abortive and discouraging. The Institute of Medical Laboratory Technology, founded in 1912 as the Pathological and Bacteriological Laboratory Assistants Association, has succeeded where others have failed, but unfortunately this body caters only for a restricted number of technicians working in the medical profession.

In February 1946 the Association of Scientific Workers, the Association of University Teachers and the British Association of Chemists called a conference in London to study the Education and Training of Science Technicians. This meeting resulted in the election of a committee to examine ways and means by which the general views expressed could be put into practical effect and to see how far existing schemes could be extended and co-ordinated.

This committee immediately appointed a technical sub-committee consisting of laboratory technicians to survey schemes of training already in operation and to draw up suggested syllabuses of courses. This sub-committee reported back to the Main Conference, who handed the papers over to the City and Guilds of London Institute to examine the advisability and feasibility of starting courses and holding examinations on a national scale.

Early in 1948 the Science Technologists Association came into operation in the presence of 154 invited members.

Technicians in many branches of science all over Britain and the Commonwealth are showing enthusiasm for the formation of the S.T.A. and its objectives. Membership is gradually increasing, and it is anticipated that eventually the Association will be very large.

It cannot be emphasised too strongly that the S.T.A. is not a trade union. The Association has been established as a professional training and certifying body for technicians in all branches outside those covered by the Institute of Medical Laboratory Technology.

The president of the Science Technologists Association is Prof. C. H. O'DONOGHUE. The vice-presidents include: Prof. H. V. A. BRISCOE, Prof. G. P. CROWDEN, Dr. J. F. J. DIPPY, Prof. A. ST. G. HUGGETT, Prof. F. W. JANE, Prof. W. R. SPURRELL, Prof. C. TYLER, and Prof. F. R. WINTON.

The Liaison Officer is E. O. ROWLAND, Geology Dept., King's College, Strand, London, W.C.2., from whom copies of the S.T.A. regulations and syllabuses for the S.T.A. Certificate Examination may be obtained, price 6*d*.

The First Transatlantic Wireless

FROM the social point of view it may be agreed that the message is more important than the means by which it is conveyed. From this standpoint, considerable interest attaches to the recent gift by Mr. P. J. Woodward to the Science Museum of a short strip of paper tape which bears the first recorded signals received across the Atlantic in the early hours of Dec. 5, 1902.

Preliminary experiments a year earlier had shown that wireless waves could travel across the Atlantic, a matter which had hitherto been much disputed but which had been settled when Marconi received the first faint signals, the single letter "S", in Newfoundland on Dec. 12, 1901, from the transmitting station at Poldhu in Cornwall.

By the following winter a powerful transmitter had been installed at Glace Bay, Cape Breton Island, and on the night of Nov. 28, 1902, Mr. P. J. Woodward, Marconi's personal receiving engineer, heard faint signals at Poldhu using the new magnetic detector and a Collier-Marr telephone. A few days later, on Dec. 5, the signals were so strong that Mr. Woodward was tempted to try recording them by means of the less sensitive coherer-receiver and morse tape-recorder. The experiment was successful and a short strip of the tape was preserved as a memento. This strip, bearing the first recorded signals received across the Atlantic, has now been added to the collections in the Science Museum.

New Method of Treating Burns

AMERICAN doctors at the Brooke Army Medical Centre at San Antonio, Texas, are now treating body burns without medication and daily changes of dressings. One new treatment being used is known as the *open method*, because a burned area is simply exposed to the healing influences of warm, dry air. A crust is formed over the burn within 24 hours. Then the patient is put on a diet with a high calorie content, which helps control his body temperature until new skin can take over its normal function. Patients with burns treated by this method suffer less pain and recover more quickly than those who get daily changes of medicated dressings. They also require less nursing care and are ready for skin-grafting sooner if that should become necessary. This treatment is particularly successful with burns that cover less than 20% of the body surface.

Another new treatment, more adapted for burns that cover more than 20% of the skin area, requires only a single dry dressing, which is wrapped tightly around the burn. Made of a new type of gauze, the dressing does not adhere to body

tissue. It is left in place for two or three weeks, until the burn is healed.

In many cases of severe burn a patient will suffer a complete loss of appetite. If this should happen, he is fed a liquid diet through a small plastic tube inserted through the nasal passage. This liquid flows into the stomach at such a slow rate that food can be assimilated without causing nausea. After the patient's appetite returns he is able to eat normal meals. Mechanical feeding is also continued, however, to provide additional thousands of calories until his burns are completely healed.

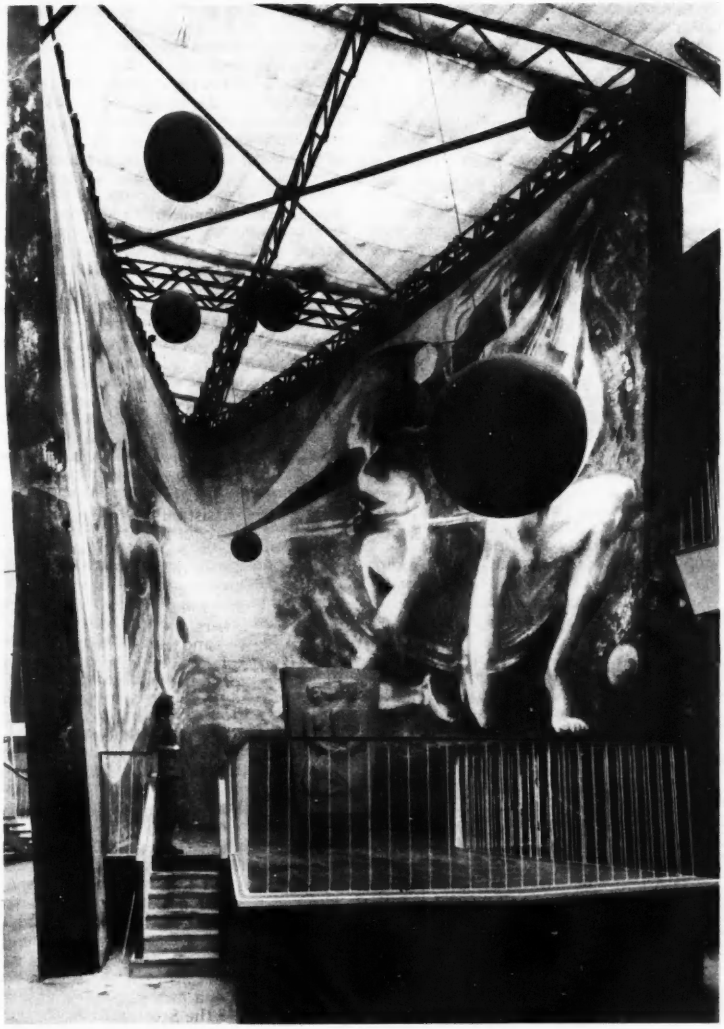
Industrial Power Exhibition

THE Exhibition of Industrial Power at Glasgow shows a resurgence of Scottish national feeling—displayed in even less orthodox form by recent events at Westminster Abbey. Here is not an old nation counting its trophies, but a young one going on a glorious rampage. Either the elders of the kirk have mellowed, or they have at last lost their grip on Gaelic youth. A team of artists and film script-writers, aided by Scottish painters and sculptors of remarkable vigour, have shaken the Kelvin Hall to its foundations with a show which, while it is magnificently factual, has also more than a hint of weird ecstasy.

Starting off with the sun as a source of power (a brilliant lamp of enormous wattage draped for some reason unknown in what looks like translucent seaweed) the visitor next finds himself in a tropical forest of the Carboniferous Age, and then in a colliery-cage, which deposits him neatly at a huge coalface. Here the history of mining, from the collection of outcrop coal, through the horrors of the Industrial Revolution, to the Mecco-Moore cutter, are passed in rapid but vividly detailed review. The Hall of Steel now follows. It is walled with a good deal of stainless-sheeting, and has innumerable steel parts imbedded in its floor. Here, complete with model Bessemer converters and similar machinery, is told the story of steel-making—which includes, incidentally, the account of how one Samuel Bentham, cannon-maker to the Czar in the eighteenth century, was led to improvise the first principles of the repeated unit-task, foundation of mass production.

More marvels follow. The shipping section, for instance, is designed as a great ship with the exhibits ranged on its decks. A delightful sense of sea and sky is conveyed here by good use of colour.

The civil engineering section, in its turn, includes an enormous waterfall; and hydro-electrics are reached through a glass tunnel (it looks like a 'Perspex' wigwam) on which a few disconsolate hoses play rather fitfully. These are a compromise between the designers' original conception of a vast cascade and sober practicality. The Highland hydro-electric schemes are shown not merely as power projects but as a social rebirth of the wilds. These features, together with panoramas of the Nile Valley, where British Engineers have undertaken a gigantic task of harnessing the waters, constitute a first-rate job. Huge turbines, in bright blue and red, form a most attractive decoration; and so does an enormous wide-gauge locomotive, which is destined for Australia, a great monster of the old school.



"The Four Elements", a mural by Michael Ayrton set in a model of the bows of a ship, is a feature of the Exhibition of Industrial Power at Glasgow.

In the final display, the "Hall of the Future", a few rather casual diagrams of the atom pay tribute to Hiroshima; but the main features is a Tesla coil, which flings a most impressive lightning flash into a dark dome of incredibly starry skies. All round the central cone are pits in which great innovators of the past—Watt, Parsons, and Rutherford for example—are seen at their labours. Viewed from above, over a low rail, their heads show clearly the varieties of hirsute genius, but little else of scientific value can be gained from those odd tableaux. The hall is retrieved by the lightning flash, and also by a really splendid mural, blazing with colour, at the far end—though its precise significance will probably evade most onlookers.

Summing up, it is fair to say that despite its tendency now and then to overreach itself, the show is grand in style, original in attack, and holds tenaciously to its central theme. This is man's conquest of power. Energy is shown flowing from its original source, the sun.

Despite a wealth of ingenious subsidiary illustration, the main argument stands out clearly. Behind the delightful extravagancies of the display, lucid and highly informed intelligences were at work. As for the sculpture, this is beyond praise, and if the mural by Alexander Zyvv (a Czech painter who now works in Scotland) is not immediately understandable —strange human profiles peer from a

design of entropy curves and gas turbine diagrams, executed in brilliant colour by a tempera technique of the Italian masters—this is, nonetheless, a high spot of the walk-round (*O tempera, o muri!*). In short, the Kelvin Hall Exhibition (which cost £200,000) is, like that at South Kensington, as near as makes no matter, first-class.

Laboratory Apparatus from Plastics

IT has been said that the rapid progress of chemistry has been possible only because of the wide utilisation of glass for the construction of apparatus. There is a good deal of truth in this claim, for glass has a unique combination of properties which makes it extremely valuable for scientific work; it is resistant to almost all chemicals, and it is transparent, so that the course of chemical reactions and other changes are easily seen. In addition it will stand quite high temperature. Moreover everyday glass apparatus—such as test tubes, beakers, funnels, bottles, and so on—can be made in very large quantities and cheaply.

Until recently the two most important alternatives to glass have been metal and ceramics. Water-baths for example are commonly made of copper. Crucibles are made from porcelain or—for certain assay purposes—platinum. Dessicators are available made from stainless steel. Evaporating dishes and the more complicated types of funnel—such as Büchner funnels—are generally made from porcelain. Fused quartz apparatus—transparent and resistant to corrosion and sudden temperature changes—is also used but its high price limits it to special purposes.

It is not surprising that the possibilities of plastics for the construction of laboratory ware early attracted attention, for the speed and cheapness with which these can be moulded in large quantities, even in the most intricate shapes, is an obvious attraction. Unfortunately, however, plastic materials possessed one serious disadvantage, which of necessity limited their use. This serious defect is their low chemical resistance. Such materials as polyvinyl chloride perspex, and casein plastic have a considerable range of chemical resistance—which makes them useful for a variety of laboratory purposes, to be discussed later—but nevertheless too restricted to permit their general use for beakers, flasks, funnels and other items of laboratory ware in constant use. Articles used as often as these must be sufficiently resistant for it to be unnecessary to think carefully each time they are used to see whether they might be attacked or not by the substances being handled. A number of plastics are also liable to contaminate solutions stored in them.

One plastic material is, however, now available which lends itself to the making of a range of laboratory ware. This is polythene, made by polymerising ethylene at exceedingly high pressures. In general it combines the extreme chemical inertness, water-repelling properties, and high electrical resistance of ordinary paraffin wax with great toughness and flexibility. Although not transparent it is translucent so that, for example, the level of liquids in thin-walled polythene containers can be seen. The temperature resistance is not comparable with that of glass but as polythene does not soften until about 120°–130°C it can be used well above the temperature of boiling water. A very great advantage—especially since the cost of glassware has risen so greatly compared with what it was before the war—is that, apart from its low initial cost, it is virtually indestructible, so that replacement of breakages is negligible. At normal temperatures it is completely resistant to hydrofluoric, hydrochloric, sulphuric, and nitric acids, and to 50% caustic soda. Polythene resists all organic solvents up to about 50°C. At 100°C. it is very slowly attacked by strong nitric and sulphuric acids, but is still completely resistant to hydrochloric and hydrofluoric acids and strong caustic soda. For these reasons polythene ware is gaining rapidly in popularity, especially in schools, factories, and other places where the bill for breakages is liable to be rather heavy. Among the apparatus now available may be mentioned funnels, beakers, and bottles in a range of sizes.

In the physical laboratory interest in polythene rather centres about its water-repelling properties and its extremely high electrical resistance. For this sort of work the raw material in the form of rod, sheet, or film is the most convenient: it can be worked with ordinary wood-working tools. Owing to its low softening temperature welded joints are easily made with a hot glass rod or a soldering iron.

Although perspex is unsuitable for making chemical apparatus—owing to its rather low resistance—it is finding many other laboratory uses, owing to its high transparency and the ease with which it can be worked. Like polythene it can be worked with ordinary carpenter's tools. It is a thermoplastic material, easily softened and bend to any required shape, which it retains permanently on cooling. Extremely strong joints can be made with 'perspex' cement. Among the uses which have been described are the making of instrument cases, thermostat tanks, and aquaria; the construction of museum exhibits and teaching demonstrations.

Another kind of plastic material which is very convenient for the construction of laboratory equipment is that made from casein by treating it with formaldehyde. Although not so resistant as perspex or polythene—being attacked by both acid and alkali—it is easily worked, is cheap, and possesses the advantage that if immersed for a short time in boiling water it softens and can be moulded to any desired shape, which it keeps permanently on cooling. It is usually supplied in the form of sheets.

Finally mention should be made of a cold-setting resin which has interesting possibilities, particularly for the physical laboratory. Although the shops are full of hundreds of different plastic mouldings which sell very cheaply these can be produced only by mass-production methods. The injection-moulding machinery costs many hundreds of pounds and only by making tens of thousands of the articles can the price be kept low. A cold-setting plastic now available—used in conjunction with an easily liquefied rubbery plastic for taking a moulding of the object which is to be copied—makes it feasible to make small numbers of plastic objects. In its original state the cold-setting plastic is a treacly liquid; when mixed with an accelerator it sets in a few hours to a glossy solid. If necessary the process of setting can be speeded up by moderate heat. As the solid plastic is easily drawn, drilled, and turned and in addition has good electrical properties it is finding many uses for the making of small electrical components, especially as wires can be fixed firmly in place by embedding them in the plastic while it is still liquid.

A Hundred Years of Aluminium

As a contribution to the Festival of Britain the ALUMINIUM DEVELOPMENT ASSOCIATION has arranged a special miniature exhibition to illustrate the phenomenal growth of aluminium from a chemical curiosity in 1851; to a metal of prime industrial importance. This is open until Sept. 28 at the A.D.A. headquarters, 33 Grosvenor St., W.1, Mondays to Fridays from 9 a.m. to 6 p.m.

The earliest exhibits typify the small successes of the industry's pioneers, on the foundation of whose labours the modern achievements of the Aluminium Industry have been built—in rather less than a century.

The story is truly international: it starts with Sir Humphry Davy who, in 1807, discussed the existence of a metal in the 'earth' derived from alum. This 'earth' was, of course, alumina (aluminium oxide) but Davy failed to isolate the metal aluminium and it was not until 1825 that Hans Christian Oersted, the Danish chemist, prepared the metal, though his sample was not pure. (The centenary of Oersted's death has just been celebrated in Denmark by the issue of a special postage stamp.)

A further 25 years passed before H. Ste. Claire Deville (in 1851 he was a chemistry professor in Paris) managed to interest Louis Napoleon and the French Academy in a method of making aluminium. His method, based on the use of metallic sodium, went into small-scale production, and the metal was shown publicly at the Paris Exposition of 1855. An aluminium medallion struck at that time is the first object in the A.D.A. Exhibition, together with a copy of the first edition of Deville's book *L'Aluminium* (1859).

Samples were also shown at the Royal Institution in May 1855, when the price was around £20 per lb.

The growth of the industry is then traced in the Exhibition by samples of metal produced in Great Britain by pioneers using the sodium reduction process.

Samples from the time of Disraeli's premiership are shown in the Exhibition, being made from metal produced by the Bell Brothers at Newcastle-on-Tyne and in much greater quantity by James Fern Webster, between 1877 and 1891, at a refinery situated near Birmingham. Towards the end of this period Webster's aluminium was being sold at £4 or £5 per lb. Some of the earliest uses of aluminium were as an alloying element, particularly

in copper, for the manufacture of hollow-ware.

Of noteworthy interest is the 'gold aluminium' cigar case shown among the early relics of the industry in this Exhibition. It is recorded that this was made by Webster tossing from his pocket a number of golden sovereigns into his pot of aluminium and the alloy was subsequently fashioned into an object of striking workmanship and beauty.

Aluminium, however, remained an expensive, indeed a precious metal, until the electrolytic process was discovered in 1886 simultaneously but independently in France by Paul Héroult, and in America by Charles Martin Hall.

The process was adopted commercially during the next ten years in France. Switzerland, America, and by the British Aluminium Co. Ltd. in Scotland. The price quickly fell from £'s per lb. to 1*s.* 8*d.* per lb. in 1894.

British production in 1896 was not more than 200 tons a year, and world output 50 years ago was between 6000 and 7000 tons a year.

First Applications

Production increased at a greater rate than utilisation, the first applications being limited by the relatively low strength of the metal. However, cooking utensils were made at a very early date as shown in the Exhibition by the reproduction of advertisements issued about 1880. In fact, Charles Dickens, writing as early as 1856 in the weekly journal *Household Words*, forecast an important future for aluminium in this field. The Exhibition includes an aluminium saucepan which has been in use for more than 50 years.

The next step was to strengthen the metal by adding small quantities of other elements to it, particularly copper, silicon, magnesium or zinc. Between 1904 and 1907 Alfred Wilm made the revolutionary discovery of the first age-hardening alloy which was taken up at an early date in Great Britain. It soon became world famous and much of the early commercial development outside Germany was carried out by Dr. Horace Clarke in this country. Dirigibles gave this high-strength alloy its first impetus and during the 1914-18 war it became increasingly important for aircraft. The first all-metal aircraft was the *Silver Streak* produced in 1920.

Another exhibit is one of the first aluminium alloy aircraft propellers made in June 1925 for the Hawker Heron machine.

The close connexion between aluminium and the aircraft industries has continued and the continual demand for improved properties and reliability by aircraft designers has led to the development of a range of alloys suited to specific requirements.

It is fitting to recall here that the process of anodic oxidation by which the surface of aluminium may be coloured and hardened was invented by Bengough and Stuart about 1920.

Today aircraft accounts for only about 10% of the total output of the industry and there has been continuous development of new uses in every field of engineering.

In shipbuilding, aluminium alloy hulls were being constructed before the turn of the century, but owing to inadequate knowledge of the properties of the alloys of those days, they were not particularly successful. With the development of the aluminium-magnesium series in the late 1920s successful marine applications were achieved, however, and the 1951 section of the Exhibition includes portions of aluminium alloy ship's plates such as are now worked in many shipyards.

Building applications developed slowly from the 1890s, but in the post-war period the tonnage of aluminium used for houses and other structures jumped ahead of all other uses. One of the most striking examples is the first all-aluminium bridge in the world opened at the Port of Sunderland in November 1948, and the choice of aluminium for the Dome of Discovery at the South Bank Exhibition is an appropriate tribute to the fitness of the metal for such purposes.

The automobile industry has been a user of aluminium since its early days. Many of the veteran cars which take part in the annual run to Brighton embody cast and wrought aluminium components which have functioned continuously since the vehicles were built.

The most complete use of aluminium on a commercial scale in a motor car to date is in the French Panhard-Dyna which took the first three places in the recent 750-cc. Class Race at Silverstone.

Overhead conductors of aluminium are another application of 50 years' standing and samples of both bare and insulated cables are exhibited after more than 30 years' service. It is of interest to note the latest addition to this field—the aluminium sheathed power cable. Radar equipment also makes extensive use of the metal.

The Chemical Basis of Muscular Action

AN 'artificial' fibre which contracts like human or animal muscle has been developed by an American biologist. In contracting, the 'artificial' muscle can lift more than 100 times its own weight. The developer of the new fibre is Assistant Professor Teru Hayashi, of Columbia University's Department of Biology. The fibre substance is called *actomyosin*, which extracted from the muscles of rabbits. Actomyosin fibres, when treated with another muscle substance called ATP, contract in the same sort of way as does living muscle tissue.

Darwin's Voyage will be Lived Again

TWELVE American technicans, led by the Scottish author Dod Osborne, are preparing to make a world cruise that will trace the sea-route followed more than a century ago by the English naturalist, Charles Darwin. On the voyage the explorers will collect scientific specimens as did Darwin. Most of the specimens will be presented to Harvard University, the American Geographical Society, and the Cincinnati Museum of Natural History. Colour films will be taken of the places visited. The films will be used by researchers in determining geographical changes in these places since they were visited by Darwin 120 years ago.

Night Sky in July

The Moon.—New moon occurs on July 4d 07h 48m, U.T., and full moon on July 18d 19h 17m. The following conjunctions with the moon take place:

July

3d 08h	Mars in conjunction with the moon,	Mars	4°	S.
5d 08h	Mercury	,, Mercury	2°	S.
8d 08h	Venus	,, Venus	0·6°	S.
10d 16h	Saturn	,, Saturn	4°	N.
24d 12h	Jupiter	,, Jupiter	5°	S.

In addition to these conjunctions with the moon, Venus is in conjunction with Regulus on July 7d 04h, Venus being 0·1° N., and Mercury is in conjunction with Regulus on July 27d 03h, Mercury being 0·6° S.

The Planets.—Mercury is an evening star setting at 20h 55m, 21h 15m and 20h 40m, at the beginning, middle and end of the month respectively, but in the first case as this is only about half an hour after sunset it will not be visible then. Venus is an evening star, the times of setting on July 1, 15 and 31 being 22h 40m, 21h 45m and 20h, 45m, respectively. Binoculars will show that the visible portion of the illuminated disk decreases from about 0·45 to 0·26 during the month, though, in spite of this, there is a slight increase in the brightness of the planet. This is due to the fact that Venus is approaching the earth, the distances on July 1 and 31 being 61 and 40 million miles, respectively. Mars is a morning star, rising at 3h, 2h 50m, and 2h 40m on July 1, 15 and 31, respectively, but in the first of these dates the rising is only 45 minutes before sunrise and the planet will not then be visible. Jupiter rises at midnight to July 1 and two hours earlier on July 31, and is easily recognised in the constellation of Pisces a little south of the stars δ and ε Saturn sets at 23h 30m on July 1 and at 21h 40m on July 31. It is easily identified, if in doubt, from the fact that it forms a triangle with the two stars β and γ. Virginis, Saturn being north of the stars.

Occultations of stars by the moon occur frequently but not always at times to suit amateur observers. On July 20d 23h 41m, that is at 11.41 p.m. G.M.T. or an hour later if Summer Time is used, the star ι Aquarii, magnitude 4·4, is occulted by the moon and 10 minutes later it reappears. The moon is more than 16 days old at the time and it may be a little difficult to see the star without binoculars. The moon gradually draws closer to the star so that her limb—the left-hand limb as you look at her—finally cuts off the light of the star which reappears later at the right-hand limb. Occultations have a great value for astronomers, enabling them to determine the moon's position in the heavens with greater accuracy. This is most essential because the movements of the moon are a little erratic and uncertain, her observed position not always coinciding exactly with her computed position.

Titanium Production

WITH the development of new production techniques American output of titanium metal (see DISCOVERY, "Old and New Titanium", by M. Schofield, May 1950), has been increased to 2000 lb. a day. This is a 100% gain in production in a few months.

Titanium is 40% lighter than iron, five times stronger than aluminium, and approximately as strong as the heavier steel alloys. It resists corrosion and it is easily welded, forged, extruded, hot-worked.

Titanium's melting point of 3140° F. is higher than that of most other metals. For this reason it is now being used in the manufacture of jet-plane engines which generate unusually high temperatures. The U.S. Navy recently developed a light-weight alloy of 92% titanium metal for use in jet aircraft. The alloy is better than aluminium for this purpose because it retains its strength at tremendous speeds.

U.S. Army Ordnance tests show that a half-inch plate of titanium resists penetration better than alloy steel of the same thickness. When exposed to salt water, titanium resists corrosion better than stainless steel, Monel metal, nickel, and chromium alloys; this makes it a valuable material in the construction of sea-going ships.

Discovered 160 years ago, titanium was first used on a large scale by American industry in the form of titanium oxide, a thick white compound used in paints. Today about 225,000 tons of titanium oxide are consumed each year by American manufacturers of paints, cosmetics, pottery, and other items; the American steel industry consumes about 2100 tons of metallic titanium each year.

New Director for Wisley

DR. HAROLD R. FLETCHER of the Royal Botanic Garden, Edinburgh, has been appointed Director of the R.H.S. Gardens at Wisley in succession to Dr. J. S. L. Gilmour, who has been appointed Director of the Cambridge Botanic Gardens.

A Historic Water Mill

A FEW years ago it was decided to construct a new reservoir in the delightful valley of the River Chew in northern Somerset, some eight miles south-east of Bristol. This work has now been started and eventually it will involve the demolition of several buildings including the eighteenth-century Stratford Mill in the parish of West Harptree. The mill has been in continuous use since 1796 and was probably built some years earlier. It is used for grinding corn, has an undershot water-wheel some twelve feet in diameter, and contains extensive and interesting apple-wood machinery. The Bristol Waterworks Company generously offered it to the City of Bristol complete with dam and sluice gates, and it is being dismantled and re-erected in the famous Blaise Gorge; it will be provided with a mill-pond and till race.

Apparently the only water mill preserved in an English museum is at the Science Museum, London, and that is incomplete and not likely to be placed on exhibition for several years.

Stratford Mill will be working to capacity up to the time scheduled for its removal, probably in late 1952.

Unesco Studies Race Relations in Brazil

IN Brazil three large ethnical groups succeed in intermingling without any apparent serious conflicts. For this reason Brazil has been selected as the object of a 'pilot-survey' as a contribution to Unesco's general study of racial problems throughout the world. Assured of a welcome by Brazilians, and the co-operation of national experts, the studies, directed by teams of sociologists and ethnologists, will be carried out during 1951 in several typical regions. Notable among these are Bahia, the peaceful rural communities of the north-east, and the large urban centres of Rio and Sao-Paulo, where the great inflow of illiterate natives as a result of rapid industrialisation presents difficult problems.

What factors, economic and political, cultural and psychological, make up the apparent harmony in the relationship between the races in Brazilian society? Scientific investigation, in clarifying these factors, will try to present an exact picture of the situation, as an example of satisfactorily solved racial conflicts. Unesco will thus have made a new contribution towards lessening the social tensions which threaten peace.

Chemicals from Waste Fuels

WORK now being done at the Fuel Research Station, Greenwich, may result in a use being found for low-grade fuels which are now wasted. An experimental plant is already working on the conversion of coal-washery slurry, a fine dirty coal, which is now a waste product, into water-gas. (This gas forms an important proportion of the gas used for domestic supplies. It is also a potential source of valuable chemical products. Among these are fuel oils and other useful hydrocarbons which can be built up chemically from the constituents of the water-gas.)

At present water-gas is produced from high-grade coke at a cost of 7d. a therm. It is estimated that the new process, if successful, could reduce this cost by as much as 50% and release 1¼ million tons of coke annually for industrial and domestic use.

The process takes place in a cylindrical metal retort in which the fine coal is heated to incandescence. Steam passed up through the cylinder reacts with the coal to form water-gas.

The difficulty of using finely divided fuels hitherto has been caused by their tendency to pack so tightly by their own weight as to become virtually solid. This has been overcome by using the "fluid bed" technique, in which the process steam is blown in from below at a pressure which keeps the fine dust in suspension and enables the steam to react with each particle.

The perfection of the process will reduce the cost of producing chemicals from coal. Countries, such as South Africa, which have large deposits of low grade coal, and low labour costs, will find the process of particular value in providing a source for many chemical products which now have to be imported.

How Birds Fly

A NEW exhibit which shows how birds fly has been arranged in the bird gallery of the Natural History Museum, South Kensington. The first two sections of the display are more or less introductory, showing, by means of models, the descent of bats and birds and flying insects from their primitive ancestors and the alteration in skeletal structure which marks the difference between a bird and a monkey. The intricate arrangement of the feather structure is also explained.

Model wings superimposed on photographs taken in a wind tunnel show how the wing is adapted to meet the air stream when a bird is in flight. Photographs and models illustrate how birds create 'lift'; how they land, soar, glide, turn and hover, and show how the shape of the wing and its proportion to body size differ according to the characteristic flight of the bird. For instance a pheasant has a strongly arched, short and broad wing which gives it additional lift when it has to climb steeply to avoid undergrowth. An interesting section describes the 'safety devices': the alula which helps to prevent 'stalling' when speed is dangerously low, and the feather pocket under the leading edge of the wing which has been copied by aircraft designers although its function is not yet fully understood.

Modern exhibition technique is admirable in evidence in this display. Photographs and models are harmoniously intermingled; caption labels are easy to read and concise; the lighting is good. A striking departure from conventional models is that of a cockerel where the skeleton is encased in plastic which indicates the body shape.

Australian Wheat in Middle East

COUNTRIES in the Middle East report great success with the rust-resisting wheat developed by the research professor in agriculture at Sydney University, Professor W. L. Waterhouse. The wheat has proved itself in the last harvest in Egypt, Cyprus and Syria, giving a high yield and showing outstanding store characteristics. The seed has been multiplied at various stations in the Middle East. It has also been tried in India and Peru.

Maleic Hydrazide Again

AMERICAN scientists consider that the new growth-regulating chemical, maleic hydrazide, according to preliminary tests, may save several million dollars in de-tasselling costs of hybrid corn. Since the chemical is a powerful hormone, scientists believe that its use may lead to the production of a male-sterile single cross hybrid.

The Bookshelf

Life of the Shore and Shallow Sea. By Douglas P. Wilson, D.Sc., F.R.P.S. (London, Nicholson & Watson, Revised edition 1951, 213 pp., 99 illustrations, 15*s*.)

WHEN the first edition of this book (1935) was published Dr. Cyril Crossland re-reviewed it in DISCOVERY and gave it his unreserved recommendation.

Dr. Wilson, whose photographs of marine animals are well known to all our readers, has replaced nearly all the original illustrations, keeping only the very best of the pictures he used in the first edition. What is more, all the photographs are *authentic*; in every case Dr. Wilson photographed the living animal or plant. (A big point, for far too many biology photos are faked; there was recently published, for example, in a leading English illustrated paper a set of photographs which were supposed to show *live* sea-horses—in actual fact every photograph in the set was of a *dead* sea-horse which had been cunningly posed to simulate the living creature!)

The first edition was described by the authors of *Between Pacific Tides* as 'the finest book of the sort that has come to our attention. The photographic illustrations . . . are little short of superb.' What more can one say of the new edition? I would go so far as to say that it is perfect; I myself can see no way in which it can be improved. Only Dr. Wilson can contradict that statement and he may do so. For Dr. Wilson is one of those rare people, a pure perfectionist, and there is always an even chance that if he ever did produce a third edition he would achieve the impossible and find some way in which to add some new and improving touches to what is already a masterpiece.

I should make it clear that both scientists and laymen will enjoy the book; more than that, they will be proud to have it on their bookshelves. Moreover, it is very good value for money.

Any connoisseur of printing is bound to remark on the marvellous quality of the blocks produced for the printing of this book. It is always difficult to do justice to photos as good as Dr. Wilson's but these blocks are so excellent that very little of that excellence can have been lost in reproduction.

WILLIAM E. DICK

Common British Fungi. By E. M. Wakefield and R. W. G. Dennis. (London, P. R. Gawthorn, 1950, 290 pp., 111 coloured plates, and 6 text-figures, 35*s*.)

EXCEPT during long periods of drought or of hard frost, there are few days in the year when some fructifications of the larger British fungi cannot be found in active growth. In warm, damp autumns, they abound in woodland, on the earth and on mouldering wood, and, less obviously, among the grass in pastures. But these common and often attractive objects are often very difficult to name correctly. Many of them soon decay, many cannot be preserved in satisfactory fashion, and many change greatly in appearance with age, or under wet or dry conditions. While some are constant in shape, others, especially many which grow on wood, are so variable in shape that this character gives little help in naming. To these special difficulties inherent in the material may be added the inconvenience that there are few books on these fungi to be bought at a price payable by the ordinary naturalist; such reasonably priced books as are available are for the most part either incomplete, or inadequately illustrated, or else, difficult to use, as they have been written by the expert for the expert.

Miss E. M. Wakefield, the Senior Mycologist of the Royal Botanic Gardens, Kew, and her colleague, Dr. R. W. G. Dennis, have produced a book which, because of its clarity of exposition, and especially because of the remarkable coloured illustrations, will be of great value to the naturalist. The book sets out to illustrate some 470 species of the common or conspicuous larger British Basidiomycetes (that is toadstools, bracket fungi, puff-balls and the like). This is about one-fifth of the probable number of British species, but of the remaining four-fifths, many are very rare, and many of doubtful status. The coloured plates, the descriptions, and the introductory matter, taken all together, should enable any user of the book to obtain reliable names for most of the larger fungi he is likely to find (provided he has not tried to identify specimens which are either too young or too old), or else to get a clue where to look in such of the larger books as may be available to him.

This excellent book may be expected to serve British Botany in at least two ways: it will spread the knowledge of the common or conspicuous species, and by making possible the identification of those species, it will not only lead to extended study of the rarer and questionable species, but it may well put a check on the multiplication of names, which has bedevilled the study of the larger British fungi.

B. BARNES

Chemical Indicators. By O. Tomicek. (London, Butterworths Scientific Publications, 1951, 258 pp., 21*s*.)

INDICATORS are great time savers and have the merit of being simple. Prof Tomicek covers the whole field of their use and outlines the current theory of their operation. His book will be mainly useful for students of chemistry who should also be grateful to the translator for the pains he has taken to incorporate British practice and experience.

Some Famous Stars. By W. M. Smart. (London, Longmans, Green & Co., 220 pp., 14 plates, 15*s*.)

The Origin of the Earth. By W. M. Smart. (London, Cambridge University Press, 240 pp., 8 plates, 12*s*. 6*d*.)

Physics of the Sun and Stars. By W. H. McCrea. (London, Hutchinson's University Library, 192 pp., 7*s*. 6*d*.)

The History of Nature. By C. F. von Weizsacker. (London, Routledge & Kegan Paul, 180 pp., 8 plates, 12*s*.)

THIS quartet of volumes offers some interesting contrasts and comparisons. To say the best thing about Professor Smart's book, *Some Famous Stars*, is the title, is not to belittle it. On the contrary; the chief difficulty faced by authors of popular texts on astronomy has been that they have all had to start from approximately the same level, and they have all reached just about the same point by the time they have used up all their space. We have been badly in need of a new design for an astronomical book, and Professor Smart has supplied it. He gives us an account of seven stars: 61 Cygni, Sirius B, Algol, Epsilon Aurigae, Delta Cephei, the novae as a group, and Delta Orionis. Any astronomer reading that list will know that an account of those stars will carry the reader beyond generalities right into the region where the observational work is being done, and the new advances made. This is a book of which both the design and execution are first class.

The Origin of the Earth, which is based on a series of lectures given to service personnel during the war, concerns itself with the structure and origin of the solar system. Possibly because of the unsatisfactory state of present theoretical ideas on these subjects, one cannot but feel that this book of Professor Smart's is not quite up to the superlative standard of his first. Nevertheless it is a workmanlike account which will be read with pleasure and interest by a large circle of readers.

Professor McCrea's book is not strictly a popular one: it is intended evidently for the more serious student and is a physical rather than a mathematical account of present ideas on stellar structure. Professor McCrea is, of course, internationally known for his own researches on these subjects, and his book is the work of a master craftsman expounding his own speciality. Almost without realising it, and without any apparent effort, one finds oneself deep into the fundamentals of stellar structure; the reader will go back to discover just how the trick was done. Not only the student, but the specialist, will read again and again, particularly the chapters on stars and stellar structure, discovering each time new implications and a new depth of insight. The book is a remarkable achievement and ought to be read by every student who wishes to acquire a balanced view of modern physics in general, and of astrophysics in particular.

Dr. von Weizsacker's text, although illustrated solely by astronomical plates, is hardly to be classed as an astronomical work. It impresses one more as a rather personal attempt to discover a stable philosophical position amid the present conflicts of science, religion and politics. It starts with the nature of physical reality,

goes on to such topics as stellar structure and the origin of the solar system, and ends with the nature of life and of the soul, and a digression into social anthropology and mythology. It is only possible profitably to discuss so wide a range of subjects in a book of encyclopaedic size, and although Dr. von Weizsacker has much to say that is interesting and novel, it is inevitable that his writing should also at times be somewhat superficial and diffuse.

DAVID S. EVANS

The Theory of Inbreeding. By R. A. Fisher (Edinburgh, Oliver and Boyd, 1949; 120 pp., 10*s*. 6*d*.)

INBREEDING, the mating of close relatives, results in an increase of the proportion of homozygotes, as opposed to heterozygotes, in a population. If continued sufficiently long it produces lines homozygous for virtually all their genes. Such lines are true-breeding and are of unique importance to breeders of crop and livestock by virtue of this reliability in breeding behaviour. They may be used directly to establish new and improved varieties in self-pollinating plants; or, in outbreeding plants and animals where inbred lines show depressed vigour and fertility, they may be used as parents for making hybrids equally uniform and predictably of high agricultural worth. They also afford a most reliable basis for progeny testing.

Professor Fisher deals with the genetical questions that arise in the production of inbred lines: questions of the rate of progress towards homozygosity under diverse and even interrupted mating systems; of the effects of linkage and enforcement of heterozygosity for a particular gene; of the most efficient way of conducting a programme when only one offspring is produced at a time, and of the size of inbreeding programmes. The treatment of necessity involves mathematics which the average biologist will at times find difficult. Perseverance will, however, be amply rewarded. Even apart from the precision given to the results by this exact treatment, some of the findings, such as the effect of interrupting a parent-offspring system of inbreeding by brother-sister mating and vice versa, could not have readily been foreseen from a merely qualitative consideration. And the explanation of how matrix algebra is used should help many to understand and use this approach.

The appendix on "The function of inbreeding in animal and plant improvement" analyses the stages of an inbreeding programme and the effects of the various possible types of selection, in relation to crop and stock improvement. It occupies only four and a half pages, but it should be read by all concerned with plant and animal breeding.

K. MATHER

DDT and Newer Persistent Insecticides. By T. F. West and G. A. Campbell. (London, Chapman & Hall, 2nd ed., 1950, pp. 632, 13 plates, 50*s*.)

THIS edition has been considerably revised by the authors to include work which has been published since the appearance of the first edition and also the work which has been done on the chlorinated hydrocarbons. Chapter I which describes the early investigations in Switzerland has been completely rewritten in the light of first-hand accounts, and Chapter II has also been revised to include the recent work of Haller and his colleagues and the Swiss workers. Part Two which deals with the newer persistent chlorinated insecticides (Benzene Hexachloride, Chlordane, Toxaphene (3956), Rhothane D3, Lethane B-71, P.C.H., benzene derivatives, Insecticide SK and Styrene dibromide) has been expanded and an additional appendix brings the literature references up to 1948.

Animal Nutrition. By C. Tyler. (Chapman & Hall Ltd., London, 1950, pp. 216, 15*s*.)

THIS little book by Professor Tyler attempts to give in the small compass of some 185 pages a review of the nutrition of farm animals. It briefly describes the process of assimilation starting with plant food and ending with an account of the conventional methods of assessing the value of feeding-stuffs to farm animals. He handles the latter, part of his subject in a logical masterly way; here he is critical and discusses new ideas in their chronological order. The illustrations leave very much to be desired.

In fairness to the author it needs to be said that he appears to have been given an impossible assignment and that in trying to please both experts and schoolboys he fell between two stools. He tried to paint a landscape on a postage stamp.

The Flight of Thunderbolts. By B. J. F. Schonland, F.R.S. (Oxford, Clarendon Press, 1950, pp. 152, VI Plates, 15*s*.)

HOW many readers of DISCOVERY have wondered with the reviewer just what a thunderbolt is? And how many will share his mild regret to learn that it is no more than the almost everyday flash of lightning? That at least is what Dr. Schonland tells us and he should know, for we now discover that he is *the* authority on lightning in history and mythology as well as the leader of modern research in the subject. This book, in fact, is a very personal monograph on the lightning flash, written with ease and grace, and viewing the bolt both from expected and unexpected angles—see, for example, how Pallas Athene and Poor Richard's Almanac jostle with point discharge in the index. It is altogether successful and can be thoroughly recommended to readers of DISCOVERY.

There are entertaining pages on thunder magic, lightning damage and the controversy, lasting about a century, on the merits of lightning rods themselves and of different designs of rods. Then we come to the study of the flash itself, that is of the optical phenomena, by special camera methods, due in principle to C. V. Boys but exploited so powerfully by the author and his colleagues. The vocabulary itself has here an appeal—*pilot streamer*, *stepped leader*, *dart leader* and *return streamer*; these are the components which the eye sees as a single stroke. The electrical processes, electron avalanches and so forth, proceeding along the path of the flash and producing the different components, are clearly described and then we come to the big question mark of the subject: 'How are the charges giving rise to the lightning produced?'

Only very tentative answers can be given, and the author rightly reserves judgment. He concludes by describing the atmospheric, what it tells us about the flash which produced it, and how it may be used, as an everyday tool, for locating thunderstorms hundreds of miles distant where observers do not necessarily exist.

P. A. SHEPPARD

A Concise History of Astronomy. By Peter Doig, F.R.A.S. (Chapman & Hall, 1950, pp. 311, 21*s*.)

THE present writer has often felt the need for some handy volume that will readily answer the questions 'who' and 'when' in astronomy, and the work under review is therefore most welcome. It does far more, of course, than answer those two questions; it is aptly named 'concise', for a remarkably wide range of topics will be found between the covers.

The book can be conveniently divided into four phases, the first occupying some fifty pages, giving the familiar account of ancient and medieval astronomy. This is followed by a rather longer section on the birth of modern astronomy during the period from Copernicus to the elder Herschel. Thus far it is easy reading for anyone interested in history or in the development of scientific thought, little astronomical knowledge being either assumed or required. To go on, however, with the story of the nineteenth century the reader should have prepared himself by the study of at least one of the many popular books on general astronomy. The final four chapters, rather more than one-third of the book, are the most exciting but at the same time the least satisfying. Here we find a compendium of the vast progress of the last fifty years, but as the treatment is necessarily brief considerable amplification, such as the same author's *Outline of Stellar Astronomy*, will be necessary to bring out its full value. References are given chapter by chapter throughout the book, and in addition a useful reading list appears at the end. The book is clearly written and well produced, misprints are few, and there is an adequate index.

For the general reader the volume brings the history of astronomy up to date. The student will find it a valuable summary and source book. As a book of reference, containing as it does some mention of the work of many lesser-known contributors to knowledge, it should find a place on the shelves of all who are interested in the growth of physical science.

E. A. B.

Climate in Everyday Life. By C. E. P. Brooks, I.S.O., D.Sc., F.R.Met.S. (London, Ernest Benn Ltd., 1950, pp. 314, 21*s.*)

As a nation we are all too familiar with the vagaries of English weather, but upon the subject of our climate we are much less eloquent; we leave it to the classroom and academic discussion. However, as the author of this new and interesting book points out, it is our climate which dictates our way of life, our habits and our outlook. Perhaps under anticyclonic gloom of the winter months, with icebound roads and power cuts we may dwell further upon our climate and our outlook.

In this book the author deals firstly with the various types of climate and the effects of varying climates upon commerce, industry and productivity. Most important is a whole chapter devoted exclusively to the siting and design of new houses and factories. It is, however, in the second and third parts of this volume that the author achieves his successful analysis of climate and everyday life. The study of deterioration of materials under different climatic conditions is of vital importance to the exporter of manufactured goods throughout the world, whilst all of us who live in or near large towns are grimly aware of the effects of atmospheric pollution. Finally there are the various ways in which we can control local climatic conditions to suit industry or to make life easier in toil or leisure.

Briefly this book contains much new and useful information, much of it the author's own recent research. In addition to the many diagrams there are appendices of climatic data. The general reader may at first sight put aside this book as being too technical; he would be wise, however, to read those parts in which he is specially interested. The book is written mainly for those engaged in factory design and siting, market research, the social and industrial planners and the student of geography, particularly the honours student. F. A. HENSON

Physics In Chemical Industry. By R. C. L. Bosworth, (London, Macmillan, 1950, pp. 928, 70*s.*)

THE formal study of chemical engineering has for a long time been based on the ideas of unit processes and unit operations. It has been successful in producing practical designers although there are many objections in logic to this method. In recent years the University courses have moved away from this division of subject to a study of more general processes such as mass transfer and energy transfer. This book is infuriating to any chemical engineer who believes that his subject has its own discipline which is suitable for undergraduate study, because it assumes that current teaching is inadequate and that physics and physical chemistry are sufficient.

In spite of this assumption, Dr. Bosworth has produced a readable and valuable book by appropriating whole sections of chemical engineering theory and integrating them, even if he calls the result physics. It has all the freshness one could expect from an Australian discovering a highly developed industry and working out for himself the rationale. If the cry is: "O my America! my newfound land" the enthusiasm is justified by the result. The general conditions for mass diffusion are stated in a way that is available in no other text-book and the discussion on heat transfer is acute and full of the simple, useful things such as the kinetic theory and the value of the Prandtl number for gases. It is the kind of book which will stimulate students in the natural and mechanical sciences to embark on chemical engineering studies. There are, however, a few points which should be noted with caution.

The transition to turbulent flow at a Reynolds number of 2100 is stated too definitely in view of the persistence of streamline flow, particularly in curved tubes, well above this value. The distillation column on p. 551 would lose an engineer his job as the downcomers are not sealed on the plate below. The terms used in the section on control theory are confusing and not consonant with the standard now in use. There are also a number of misprints to be corrected, such as the international kilometer, amoricium, R. A. Fischer, Fich and Rashig. The book is otherwise well-produced and thought-provoking. F. E. WARNER

A Modern Electricity. By M. Nelkon, M.Sc. (London, Heinemann, 1950, 234 pp., 7*s.* 6*d.*)

THIS is a straightforward text up to General Certificate standard and written by an experienced teacher and author of text-books. It is very clearly illustrated with the customary circuit diagrams and simple representations of elementary experiments and instruments, and follows the orthodox sequence from magnetism through electrostatics and current electricity to electromagnetics and alternating current. The last chapter deals with electronic devices. There are many exercises, to which answers are provided.

The author has added touches of something different to distinguish his book from other text-books. He brings in historical material, a welcome sign, though one may wonder how the mere listing of names and discoveries can do more beyond supplying extra facts for examination purposes. He also claims an emphasis on the social importance of fundamental discoveries, but it is difficult to find just where this claim is substantiated. For example, in connexion with electric light the author shows no awareness whatever of the fact that this has caused a revolution in social habits now that we have successfully turned night into day. Surely this is a social effect of great and interesting importance! Yet the author's text on the filament lamp occupies barely *fourteen* lines in the whole book.

The truth seems to be that the historical material and the claim to emphasis on social importance are introduced as something 'modern' to make the text palatable. There is nothing to be said against such a procedure—far from it—but one would be more impressed by a *true* modernity, that is, by awareness of recent research. For instance, the author's explanation of magnetism in terms of molecules that act as tiny magnets is hallowed by great age and is quite out of date. Where are the molecules in a metal such as pure iron? The author shows no sign that he has heard of modern electronic theories of magnetism, including the 'domain' theory of ferromagnetism.

So this is in fact just another text-book, albeit an attractive one, suitable for anyone taking an examination of the standard indicated. C. L. BOLTZ

The Coming of the Flowers. By A. W. Anderson. (London, Williams and Norgate, 1950, 267 pp., 10*s.* 6*d.*)

THIS is a lovely little history of many of our garden flowers. Written by the Curator of the Botanical Gardens at Timaru, New Zealand, it will be enjoyed by most plant lovers and botanists.

The book ties the history of botany into our social history; for instance, the reader will discover, probably to his surprise, all about the botanical significance of Bligh's famous mutinous voyage on the *Bounty* —Captain Bligh was a protégé of Sir Joseph Banks and the main purpose of the trip was to spread breadfruit trees from Tahiti through the fast-developing West Indies. Six months were spent on Tahiti (it was the stay on this voluptuous island that sowed the seeds of the mutiny), and over a thousand breadfruit trees were stowed aboard, together with hundreds of plants destined for the Royal Gardens at Kew. But the great venture in economic botany was wrecked by the mutiny. One of the expedition's botanists, David Nelson, died during the voyage; Nelson had previously introduced a kind of grapefruit from India into the West Indies, and before his death he had the satisfaction of seeing these so-called 'Shaddock trees' flourishing and fruiting on Tahiti. The other botanist, William Brown, went with Fletcher Christian, leader of the mutiny, to Pitcairn Island; during their early days on that island he identified plants of economic value and he taught the mutineers how to grow crops. He met his death in a dispute over land ownership.

An Introduction to Servo Mechanisms. By A. Porter. (Methuen & Co. Ltd., 1950, pp. 154, and 70 diagrams, 7*s.* 6*d.*)

SINCE the quantitative aspect of this book goes rather beyond the aim of explaining broadly what servo work is about, it may prove heavy reading to "the physicist, physiologist, engineer, etc., who is merely interested in the subject" to whom the book is offered in the Preface. But it does serve as a useful introduction to the subject, and its considerable and up-to-date list of references will enable the serious worker to plan his own course of further study. Two warnings to such readers are that they would be well advised to study the Laplace transform and 'complex-frequency plane' (which are explicitly avoided here) and that they will eventually have to gain possession of the ideas behind the work of Norbert Wiener, who is not mentioned. D. A. BELL

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